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APPLICATION OF THE BROMATE DIFFERENTIAL TEST IN THE ESTIMATION OF BAKING QUALITY OF CANADIAN HARD RED SPRING WHEAT FLOUR*

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The constant strong demand in the markets of the world for Canadian hard red spring wheat is based upon the fact that this wheat can be milled into flour of very high strength or quality. Flour strength has been defined by Humphries (6) as the capacity to produce large, well-piled loaves. It is well known, however, that the quality of wheat depends largely upon the conditions under which it is grown, and consequently it is very desirable to have criteria by which to estimate this characteristic, in order that the producer may secure a just price, and that the consumer may receive all that for which he pays. No matter how wheat may be evaluated for marketing, the final judgment in regard to strength lies with those who actually bake the flour into bread. The miller cannot wait for public opinion to pass judgment upon his product, but must know beforehand the characteristics of the wheat which he intends using, in order that the quality of the flour produced may be kept up to standard.

The classification of wheat into grades, by referance to external appearance, is the most commonly used criterion of quality at present. Most large mills in America go further, and test the wheat for quantity of protein, since this is believed to be closely correlated with the baking quality of flour. These two methods for estimating the probable strength of the flour which may be produced can be applied rapidly to the wheat, and by consequence are in most general use. However, these methods give at best only approximations, and merely serve to make rough classifications of wheat. For more precise estimation of the characteristics of wheat, the experimental milling and baking procedures were developed.

In experimental milling, a sample of wheat, usually about 4½ pounds in weight, is milled into flour by a procedure as nearly like that of a commercial mill as is compatible with the use of a small milling unit. The flour thus produced is comparable to commercially milled flour of the same extraction. It is of course untreated by bleaching agents, and must be matured by natural ageing. The specific procedure for milling may vary considerably in minor details in different laboratories, but from its very nature the method in general principle must be fairly uniform. The same cannot be

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said of the baking test. Here there are many variables which may profoundly affect the final results, and it is not surprising that until quite recently, nearly every laboratory had developed a procedure of its own. In 1926 the American Association of Cereal Chemists appointed a Committee to investigate the experimental baking methods in use, and the possibility of developing some standardized procedure whereby the results from different laboratories would be comparable. As a result of their work, the Committee (*2*) proposed a tentative standard basic procedure in which all the variables would be rigidly fixed. It is hoped that in this way, any variation in the results obtained may be attributed directly to the flour itself. A number of modifications of the basic procedure, designed to meet special cases and to give more complete information where desired, were also suggested. This paper deals with the use of the alternative test C, the bromate differential test, as a means for evaluating baking quality of Canadian hard red spring wheats.

The bromate differential baking test was first used by Werner (*7*). It consists in baking the flour by use of two formulae, namely the simple basic formula comprising:

Flour	100	grams (15 per cent moisture basis)
Yeast	3	grams
Salt	1	gram
Sugar	2.5	grams
Water	58	per cent.

and the foregoing formula plus 1 mgm. of $KBrO_3$. In all other respects the bakings are carried out under identical conditions.

$KBrO_3$ is an oxidizer, and in its action on flour is somewhat representative of a fairly large number of compounds classed in general as "flour improvers". In cases where it is effective, its action is expressed in increased loaf volume, improved texture and colour, and sometimes in improved crust colour of the bread.

Blish and Sandstedt (*3*), although they submitted no data, have discussed the method. They pointed out that "flour showing the greatest stimulation in the differential test may be regarded as the least susceptible to overtreatment by the miller and vice versa." They state that their observation is to the effect that the degree of stimulation is roughly proportional to the protein content, and add that this fact may constitute the foundation for the practice of paying premiums for high protein wheat. They suggest furthermore that the test might prove useful in the commercial bakeshop, as a means for determining how much further stimulation, if any, can be induced in any given flour.

Herman (*5*) states that "flours from the experimental mill giving positive reaction (to the differential baking test) are the products of wheats desirable for the commercial milling of so-called bread flours." Werner and Herman (*8*) in discussing the differential baking test make the following statement: "It may generally be stated that flours non-responsive to the plus test (with bromate or Arkady) will be found lacking under commercial usage

in what is termed by the practical baker strength or stability. As a rule they will not respond well to yeast foods or to severe treatment."

Quite recently Working (*10*) has propounded an interesting hypothesis to account for the action of oxidizers on dough. He explains the improvement as being due to some action of the oxidizer on the phosphatides present in the flour whereby the latter are made more soluble. This, according to his theory of the production of good bread (*9*) should result in improvement of baking quality, unless an excess of the phosphatides were made available, in which case there would be a decrease.

Whatever the fundamental cause of the results produced by oxidizers, the fact remains that in many cases there is obtained a very remarkable improvement in bread by use of various substances generally classed as flour improvers, and the immediate consideration is to discover how to turn this fact to use in the estimation of the baking quality of flour. In baking experimentally milled flours from western Canadian hard red spring wheats by the use of a simple formula involving only flour, yeast, salt, sugar and water, the data obtained are sometimes rather incongruous. Samples of Marquis wheat of high grade and high protein content, grown in districts having the reputation of producing the highest quality wheat, have given by this procedure results no better than what might be obtained with wheats of very mediocre quality. These wheats often possess idosyncrasies of an unknown nature, which show up when the untreated flour is baked by a simple basic procedure, but which fail to appear either when the wheat is used in blends with lower grade wheats, or when the flour is bleached or treated in the baking procedure with some form of oxidizer. In consequence the experimental milling and baking test as commonly used often discounts wheat and flour which the miller and baker would pronounce as of the finest quality.

In view of these considerations it was thought to be very necessary to make a thorough study of various methods of baking in order to arrive, if possible, at a procedure which would give a reasonably accurate estimate of the actual quality of wheat from the standpoint of the miller and baker. In such a study it is highly desirable that the material used should be of known history and should be as far as possible uniform in regard to inherited characteristics. Varietal differences and modifications due to various forms of damage introduce variants which cannot be evaluated, and which must vitiate the results obtained. Accordingly there were selected 24 samples of flour representing 75 per cent patent experimentally milled from wheat grown in plots in various parts of Saskatchewan in the years 1926 and 1927. These samples were all grown from the same lot of seed, of a very pure strain of Marquis, by men especially chosen for their reliability. In addition to these 24 samples, there were included in the series two samples of commercially milled flour, one unbleached, the other bleached and both aged for one year; a sample of flour milled from Pacific White Club wheat; one milled from a very poor sample of rusted Garnet wheat, and one milled from another pure strain of Marquis wheat. The Marquis samples were part of a much larger number grown in a similar manner, and

these particular samples were chosen because they exhibited the greatest range in protein content and apparent baking quality (as previously determined by the simple basic procedure). A full description of the material used is given in Table 1.

The experimentally milled flours were all aged for 3 months before baking.

The baking procedure used was a modification of the "Basic Standard Procedure" described by Blish (*1*). The fermentation and proof times, and all temperatures, were according to the Blish method. The points of departure from the above consisted in mixing the doughs in a Hobart mixer for four minutes, instead of mixing by hand, and in using the following formula:

Flour	50 grams (13.5 per cent moisture basis)
Yeast	1.5 grams
Sugar	1.25 grams
Salt	0.5 grams
Water as required for proper consistency.	

The loaves were baked in low tins of the dimensions:

Top 10 x 6.3 cm.
Bottom 7.5 x 4.3 cm.
Depth 4 cm.

The machine mixing is done in the interest of time and uniformity, and

TABLE 1. *Description of wheat samples.*

No.	Variety	Grade	Weight per measured bushel (lbs.)	Crude* protein of wheat (per cent)	Remarks
1	Marquis 10b - 1926	2°	61	16.2	
2	"	1°	63½	13.1	
3	"	1 hard	66½	13.8	
4	"	1°	66½	15.7	
5	"	1°	65	14.5	
6	"	2°	59½	15.3	
7	"	1°	66½	12.4	
8	"	1°	64½	15.5	
9	"	1°	66	13.4	
10	"	3°	62	16.8	Sprouted
11	"	2°	60	17.4	
12	Marquis 10b - 1927	2°	66	11.2	
13	"	#5	56½	14.4	Rusted
14	"	3°	65	11.7	
15	"	3° good	66	12.9	
16	"	3°	65	15.6	
17	"	1°	66	14.0	
18	"	3°	64	12.6	
19	"	2°	64	13.5	
20	"	2°	64	14.0	
21	"	#4	57½	12.6	Rusted
22	"	2°	61	11.7	
23	"	3°	62	11.8	Weathered
24	First patent flour unbleached.				
25	First patent flour bleached.				
26	Marquis Ottawa 15 - 1927	3°	64½	14.3	
27	Pacific White Club				
28	Marquis 10b - 1927	#4	60	11.4	Left in stook over winter.
30	Garnet - 1927	#5	57	8.5	Rusted

*Calculated to 13.5 per cent moisture basis.

is used on the 100 gram loaves as well. The use of the smaller loaves was adopted through necessity. The number of bakings which had to be made on these flours in this and other studies was so great that with the 100 gram batch, the available supply of material would have been exhausted long before the necessary bakes were completed. It is not used in the regular work of this laboratory. Its only use is in cases such as this, when the supply of material is strictly limited and a large number of bakings are required. A comparison of the baking of the 100 gram and the 50 gram batches is given in Table 2. These results show that the loaf volume obtained by the 50 gram batch is slightly less than half of that for the 100 gram batch, but the difference is not nearly so great as might be expected. In general, the texture of the smaller loaves is somewhat better, and this results in the final computed baking scores being very nearly equal. For the present study, the chief consideration is that the relative values should be similar, and this indeed appears to be the case. The coefficient of correlation of the two series of computed baking scores is:

$$r_{xy} = +0.95 \pm 0.016.$$

It has been found nearly imposible to bake such a series of variable flours at a constant absorption, and it is not attempted when the supply of flour is limited.

Potassium bromate, when used, was added in solution by means of a pipette. The concentration was constant at 0.001 per cent or 0.0005 grams per loaf.

TABLE 2. *Comparison of 100 gram and 50 gram loaves by our modification of Blish's method.*

	100 gram loaves					50 gram loaves				
Sample No.	Texture	Crumb Colour	Appearance	Loaf Vol. cc.	Computed Baking Score	Texture	Crumb Colour	Appearance	Loaf Vol. cc.	Computed Baking Score
9	8.5	10	7.5	553	85	9	9.5	9	255	79
10	6	10	6.5	603	86	6	8.8	8	290	81
11	8	9.5	7	595	91	8.5	8.8	9	290	90
12	9.3	9.8	8	533	84	10	9.8	7.5	263	84
13	9	9.8	8	638	104	9.3	8.8	8.5	313	100
14	9	9.8	7.5	565	89	9	9	9	268	82
15	8	10	7.5	520	77	9.5	8.8	8	249	75
16	7	9	6	540	74	8.8	8.5	8	263	78
17	9	10	8	540	84	9.5	9	9	267	84
18	8	9	6	485	66	9	8.5	7.5	228	64
19	10	9.8	8	563	92	10	9.5	8	283	91
20	8.5	9.8	9	595	95	9.3	8.8	8.5	275	85
21	10	9.5	9.5	620	103	10	8.5	9.5	305	100
22	9	9.8	7.5	540	84	9.8	8.5	7.5	263	81
23	10	9.8	9.5	618	104	9.8	9.3	9	303	100
24	10	10	9	645	115	10	10	9.5	315	113
26	9	11	6	523	85	9	10	7.5	278	91

The whole series was baked on one day and repeated on the following day. Bakes which failed to agree within 10 cc. were again repeated. The baking with addition of bromate was carried out in a similar manner. All loaves were scored against No. 24 which has been used as the standard for a year and has been found to be very constant in volume, texture, colour and appearance.

In scoring texture, crumb colour and appearance, the range used is from 0 for rejected to 10 for excellent. Loaf volume is determined by use of a modified hour-glass apparatus similar to the one described by Geddes and Binnington (4). The computed baking score is calculated empirically from the other scores by the following method:*

(Loaf volume minus 200)	×	0.4
Texture	×	3
Crumb Colour	×	2
Appearance	×	1
(Absorption minus 60)	×	1

Total=Computed Baking Score.

When dealing with the larger loaves, baked with the 100 gram formula, the loaf volume calculation is changed to:

(Loaf volume minus 400) ..... × 0.2

and the other scores are calculated as above.

When comparing flours it is very necessary to take cognizance of all the chief characteristics of the baked loaf. It has become a rather prevalent custom to record a number of scores but to consider only the loaf volume figure in making comparisons for the purpose of drawing deductions. If, as is generally believed, the other factors possess any significance, they should not be wholly disregarded, but it is exceedingly difficult to use a number of separate scores in attempting to estimate the relative values of a series of flours. The system of calculation outlined above, while being quite empirical, is thought to give a fairly useful relative weighing of the various scores used in experimental baking, and the net score so obtained is very convenient in making comparisons.

The data obtained by the differential bromate test on the series of flours described heretofore, are set forth in Table 3. These flours may be divided into three classes according to their response to the bromate:

I. Those responding negatively.
II. Those showing a significant positive response.
III. Those exhibiting little or no significant effect.

For the purpose of this discussion, it will be considered that a variation of 3 per cent or less is not significant.

In order to facilitate reference, the data of Table 3 are re-arranged and summarized in Table 4.

Samples 27 and 30 have been omitted from Table 4 because it is thought that the actual changes are not significant. The percentage change appears disportionately large due to the fact that the initial scores in both cases were so very low. Neither of these would be accepted as bread flours.

In examining these data, attention should be directed first to the fact that many of the flours milled from wheat of high grade and high protein gave very low scores by the standard basic procedure, and as a result of that baking alone, some of them, such as Nos. 1, 5 and 8, would be classified as of very poor quality. Most of these flours when baked with the addition of 0.001 per cent $KBrO_3$ showed a remarkable improvement in all respects and if judged by this latter test would be classified as from very fair to excellent in baking quality.

*This method was developed by the Sub-committee on Laboratory Methods of the Associate Committee on Grain Research on December 6, 1928, and was proposed for tentative use of the four collaborating laboratories of the Committee.

TABLE 3. *Baking data obtained by use of the differential baking test.*

No.	Absorption %	Basic Formula					Bromate Formula Basic Formula + 0.001% $KBrO_3$					Percentage Increase
		Loaf Volume cc.	Texture	Crumb Colour	Appearance	Computed Baking Score	Loaf Volume cc.	Texture	Crumb Colour	Appearance	Computed Baking Score	
1	60	225	8	8.5	8	59	325	9	9	10	105	78
2	60	248	8	9	8.5	71	298	10	10	8.5	98	38
3	61	230	9	9	8	66	282	10	10	9.5	93	41
4	61	233	8	9	7	63	305	10	9.5	9	101	60
5	59	225	8	8	6.5	56	290	9	9	8.5	89	59
6	61	320	10	10	8.5	108	333	9	9.5	9	110	2
7	61	250	7	9	7.5	68	275	10	10	7	88	30
8	61	215	7.5	8.5	6	53	265	10	9	8.5	84	58
9	61	255	9	9.5	9	78						
10	61	290	6	9	8	81	418	8.5	10.5	9	144	78
11	61	290	8.5	9	9	90	344	9	9	10	114	27
12	61	263	10	10	7.5	84	270	10	9.5	8	86	2
13	61	308	9	9	9	98	322	9	9.5	8	105	7
14	61	268	9	9	9	82	278	10	9.5	7	89	9
15	61	249	9.5	9	8	75	282	10	9	7	89	19
16	61	263	9	8.5	8	78	305	9	9	8.5	97	24
17	61	267	9.5	9	9	84	295	9.5	10	8.5	96	14
18	61	233	8	9	8	64	275	9	9	7.5	84	31
19	61	283	10	9.5	8	91	288	9	10	8	91	0
20	61	275	9	9	8.5	85	338	10	9.5	9	115	35
21	61	305	10	8.5	9	100	305	9.5	9	9.5	99	–1
22	61	263	10	8.5	7.5	81	260	9.5	10	7.5	81	0
23	61	303	10	9	9	99	300	9.5	10	8.5	98	–1
24	67	315	10	10	9.5	113	322	9.5	9.5	9	113	0
25	77	303	10	11	10	121	310	10	10.5	9.5	122	1
26	65	278	9	10	7.5	91	255	10	10	7.5	84	–8
27	51	175	1	2.5	0	–11	173	3	1.5	0	–7	36
28	57	297	10	8	8	90	270	10	8	8.5	80	–11
30	59	210	5	4	6	32	192	6	4.5	5.5	29	–10

TABLE 4. *Percentage increase of computed baking score by the bromate formula over the computed baking score by the standard basic formula.*

Class I.		Class II.		Class III.	
Flour No.	Per cent Increase	Flour No.	Per cent Increase	Flour No.	Per cent Increase
26	–8	1	78	6	2
28	–11	10	78	12	2
		4	60	19	0
		5	59	22	0
		8	58	24	0
		3	41	25	1
		2	38	21	–1
		20	35	23	–1
		18	31		
		7	30		
		11	27		
		16	24		
		15	19		
		17	14		
		14	9		
		13	7		

In Class III there are 8 samples which show little if any change due to the bromate. In all these cases except for No. 22, the flours showed high quality by the basic procedure. The two commercial flours, Nos. 24 and 25, gave no significant response whatever. It has been found that flours which bake up very well by the basic formula frequently fail to respond positively to the differential test. Flours giving low or intermediate values by the basic formula may be greatly stimulated by bromate as is shown by the flours of Class II, or they may be unable to respond further, as in Class III or again they may respond negatively as in Class I. Negative responses to the differential baking test as conducted in this work clearly indicate inherent weakness of the flour or weakness due to some form of damage. Table 5 gives data obtained by means of the bromate differential test, on flours showing weakness due to various forms of damage.

In most of these cases, the values obtained for loaf volume by the basic formula indicate good quality, but very marked decreases in loaf volume occur when the bromate formula is used.

Sample 28 was milled from wheat which had been left in the stook during the winter and had, it so happened, an exceptionally severe exposure to rains during the autumn. It was baked shortly after milling and showed a very high baking score. Several months later the same flour was baked again and was found to have decreased very materially in strength as indicated by very much lower loaf volume. This suggests unsoundness, but even after six months storage the flour still exhibited a fairly high degree of strength as evidenced by the score of 90. When baked by the bromate formula it gave a further decrease of over 10 per cent. This seemed to indicate that the differential test might prove useful in exposing weaknesses of flour which could not readily be detected by the basic formula. Data subsequently obtained and partly recorded in Table 5 abundantly support this assumption.

Sample No. 27100 presents perhaps the most striking case observed to date. This flour was milled from wheat of known history and, from information which was available, it seemed as though it should have been some-

TABLE 5. *Application of the bromate differential baking test to flours of low strength and to flours showing various forms of damage.*

Laboratory No.	Apparent Cause of Damage or Weakness		Absorption %	Loaf‡ Volume cc.	Grain and Texture	Crumb Colour	Appearance	Computed Baking Score	Decrease in Com. Bak. Score	Per cent Decerease
28	Excessive weathering	A*	57	594	10	8	8	90		
		B*	57	540	10	8	8	80	10	11
2829b	Uncertain—probably rust	A	63	417	1	1	6	17		
		B	63	375	1	1	5	8	9	53
28189	Frost	A	67	540	6	4	10	71		
		B	67	479	5.5	4	10	57	14	20
28199	Frost	A	75	492	2	2	6	49		
		B	75	432	2	2	6	37	12	24
27102†	Sprouting	A	58	616	0	6	10	63		
		B	58	516	0	3	8	35	28	44
27101†	Sprouting and mould	A	60	640	0	8	8	76		
		B	60	524	0	8	9	51	25	33
27100	Probably sprouting	A	61	624	10	9	10	104		
		B	61	560	7	9	9	81	23	22
28528	Improper drying	A	63	470	8.5	9.5	7	68		
		B	63	440	8	9	7	60	8	12
28530	Improper drying	A	63	520	9	9	8	80		
		B	63	460	7	9	8	62	18	22
28536	Improper drying	A	63	446	7.5	9	8	61		
		B	63	395	6.5	8	7	45	16	26
2730	Blend of hard and soft wheats	A	57	620	10	10.5	8	100		
	—highly bleached	B	57	555	10	10.5	7	86	14	14

*A refers to the basic formula and B to the bromate formula.
†Texture for these two samples was scored 0 because of stickiness of the crumb.
‡100 gram formula.

what unsound. Bakings at various intervals, as in the case of No. 28, failed to reveal any sign of decrease in strength, and the conclusion from the results in hand was that the flour was of very good quality. When, however, it was found to respond to bromate in much the same manner as No. 28 and to a somewhat greater extent, it was concluded that some damage must have actually occurred.

In considering flours which give positive responses to the action of bromate, it should be noted that in Table 3, all such flours with the exception of No. 13 were experimentally milled from high grade wheat of good protein content. There was every reason to predict that the various samples of wheat would yield flour of high strength. Many of them were grown in the finest wheat producing area of Saskatchewan. No. 1, for instance, was grown in the southwestern part of the province. It is high in protein. It graded 2°, weighed 61 lbs. per measured bushel, and judged by all our customary standards, could be pronounced high in quality, but the flour tested by the basic formula would be regarded as very weak. Numerous similar cases might be selected from those given in Table 3.

A single case might be regarded as an exception due to some unknown peculiarity of the soil or climate conditions under which it had been grown, but when the majority of these wheat samples, grown in widely separated parts of the province, show low quality by the basic formula there is ground for doubting the value of this test alone as a means for estimating the worth of such samples. The tremendous response to stimulation by the bromate indicated by the score by the bromate formula are by no means the limit to which these flours may be stimulated. This series was baked by a formula comprising the basic formula to which was added 0.5 per cent Arkady and 3 per cent of diastatic malt extract. The results obtained are given in Table 6.

The treatment by this formula was quite severe. The commercial flours, Nos. 24 and 25, were unable to stand up to it and some of the others which gave little or no response to the bromate formula showed decreases in computed baking score. Without exception those flours which gave a positive response to the bromate greater than 10 per cent showed still greater stimulation by the Arkady and malt formula. That the magnitudes of the response by the two formulae are closely related is shown by the high coefficient of correlation for these two series of figures:

$$r_{xy} = +0.92 \pm 0.020.$$

Although the number of cases considered is small, in view of this high correlation coefficient, it seems safe to say that in general those flours which exhibit a pronounced improvement due to bromate will also respond very vigorously to Arkady and malt, and that those which respond indifferently, if at all, to bromate, will perform similarly with Arkady and malt. If this latter formula is at all comparable to commercial bakeshop practice, it is evident that the bromate differential baking test gives a fairly good estimate of the ability of flours to stand up under commercial use.

At this point there might be brought forward as a criticism the fact that the foregoing conclusions were drawn from data obtained with ex-

TABLE 6 *Experimental series baked with 0.5 per cent Arkady + 3 per cent Malt.*

Sample No.	Absorption %	Loaf Volume cc.	Texture	Crumb Color	Appearance	Computed Baking Score	Per cent increase over score by Basic Formula
1*							
2	60	320	9	9	10	103	45
3	61	303	10	9.5	10	101	53
4	61	358	10	10	10	124	97
5	58	350	9.5	9	10	116	107
6*							
7	61	305	9.5	9.5	9	100	47
8	61	333	10	10	10	114	115
9*							
10	61	438	8.5	10.5	10	152	87
11	61	405	8.5	9.5	10	138	53
12	61	263	9	9	8	79	–6
13	61	343	9.5	9	9	114	16
14	61	260	8.5	8.5	8	76	–7
15	61	330	10	10	10	113	51
16	61	368	9	10	10	124	59
17	61	300	10	10	10	100	19
18	61	328	10	9	10	111	73
19	61	300	10	10	10	101	11
20	61	343	10	10	10	118	39
21	61	315	9	9	10	102	2
22	61	265	10	9	10	85	5
23	61	293	9	9	10	93	–6
24	67	308	9	9	10	104	–8
25	77	290	8.5	10.5	10	110	–9
26	65	282	10	10	10	98	8
27	51	215	2.5	4	2	15	
28	57	288	9.5	7.5	10	85	–5
30	59	200	5.5	4	6	30	–6

*Omitted on account of shortage of flour.

perimental flours and that these are considerably different from the products of commercial mills. A fairly large number of commercially milled flours have been tested in this laboratory by the bromate differential test. Some of the results which are given in Table 7 are extremely interesting from the point of view of this discussion.

These data are quite typical. Most unbleached commercially milled flours behave similarly to those experimentally milled inasmuch as they show a low score by the basic procedure and respond vigorously to the bromate formula. Bleached flours, on the other hand, react to bromate rather indifferently, giving either slight negative or positive responses or no significant response at all. The obvious deduction is that due either to the bleaching process or to superior blending, certain flours in the course of manufacture are developed to nearly their maximum strength since they show excellent quality by the simple formula and fail to respond to any extent when submitted to the action of an improver. Other flours are turned out with part of their potential value undeveloped.

The problem which now arises is to decide whether the bromate formula or the basic formula gives the more nearly correct estimate of the baking value of the flour. Any test of raw materials or of finished products should be conducted from the point of view of the use for which the material is ultimately intended. Flour is rarely manufactured without undergoing

some sort of bleaching or maturing process, and it is rarely baked commercially without the use of improvers or yeast nutrients. In applying a simple basic formula to experimentally milled flours, neither of these points is taken into consideration. Therefore, in order to evaluate flours by this method, one must assume that the baking values so obtained give an accurate estimate of the magnitude of the response which might be expected when the material is submitted to stimulation by the various substances used in the manufacture of bread. This assumption appears not to be borne out by the data obtained in this laboratory. In our experience there is no means for predicting from the results of the basic procedure, what values may be obtained by a formula containing a flour improver or yeast nutrient. The coefficient of correlation for the computed baking score by the basic formula and the percentage difference obtained by the bromate formula calculated for the data of Tables 3, 5 and 7 (excepting No. 27 of Table 3) was found to be

$$r_{xy} = -0.28 \pm 0.089.$$

This value indicates that there is very little relationship between the baking score by the basic formula and the degree of stimulation by bromate, and bears out our statement that it is impossible to predict from the results of the basic procedure, the probable behaviour of a flour when submitted to commercial usage.

As a result of the work reported here, the conclusion has been reached that data in regard to experimentally milled flours obtained by use of a simple formula of salt, sugar, yeast, flour and water only, are by no means complete or satisfactory, since they fail to give a definite measure of the final results obtainable by use of commercial formulae. On the other hand however, a single baking with a formula containing stimulants of some sort would be unsatisfactory because it would give no indication of the degree of response which the flour underwent to attain the final value observed. If the response of the flour is indicative of the value of the wheat for commercial purposes, it seems highly desirable to determine it, and this can be done only by means of the differential baking test. In assigning a definite baking value to milled flour, it seems more reasonable to use the value obtained by the bromate or some similar formula. In determining the intrinsic value of a given sample of wheat however, the magnitude and direction of the response of the flour should be known. Just how this is to be applied to the evaluation of wheat in regard to strength has yet to be determined. Work along this line is in progress in this laboratory at present.

Summary and Conclusions

In baking experimentally milled flours, a simple basic formula alone gives insufficient information, inasmuch as it fails to show the potentialities of these flours when submitted to commercial usage.

The basic formula plus 0.001 per cent $KBrO_3$ gives a more accurate estimate of the baking values of flours, since it more nearly approximates commercial practice.

TABLE 7. *The differential baking test applied to various commercial flours milled from Saskatchewan wheat.*

Laboratory No.	Description		Absorption %	Loaf‡ Volume cc.	Grain and Texture	Crumb Colour	Appearance	Computed Baking Score	Difference B - A	Per cent Increase
2829a	Straight—unbleached	A*	61	597	6	8	9	83		
		B*	61	695	10	9	10	107	26	31
2829c	Straight—unbleached	A	59	467	3	4	8	37		
		B	59	490	7	5	8	56	19	51
2828	Straight—unbleached	A	61	490	5	6	9	55		
		B	61	545	10	9	9	87	32	58
28144	Straight—unbleached	A	65	635	10	10	10	112		
		B	65	663	10	10	10	118	6	5
28200	Straight—unbleached	A	67	500	4	1	6	47		
		B	67	594	7	1	7	77	30	63
28204	Straight—unbleached	A	63	560	7	6	8	76		
		B	63	680	10	8	10	115	39	51
2830	1st patent—bleached	A	61	592	9	11	10	98		
		B	61	605	10	11	9	103	5	5
2831	Export straight bleached	A	61	590	8	8	10	89		
		B	61	625	10	9	10	104	15	16
279	Baker's patent bleached	A	63	660	9.5	9	10	111		
		B	63	630	10	10	10	109	–2	–2
276	2nd patent bleached	A	60	615	10	10	10	103		
		B	60	607	10	10.5	10	102	–1	–1
275	Baker's patent bleached	A	59	635	10	9.5	10	105		
		B	59	655	10	10	10	110	5	5
274	1st patent bleached	A	60	637	10	11	10	109		
		B	60	585	10	10.5	9	97	–12	–11
277	1st patent bleached	A	62	633	9.5	10.5	9	107		
		B	62	595	10	10.5	8	100	–7	–6

*A refers to the basic formula; B to the bromate formula.
‡100 gram formula.

The differential baking test, in which each of these formulae is used, gives a measure of the degree of stimulation possible for a flour, and in experimental testing of wheat for quality this method is to be recommended. By its use flours may be grouped generally into three classes, namely:

(1) Those showing negative response. In such cases inherent weakness or weakness due to some sort of damage is indicated.

(2) Those showing marked positive response. Most of the flours experimentally milled from sound, high quality, hard wheats belong to this group. The magnitude of the response of these flours seems to be somewhat related to the protein content. The coefficient of correlation between crude protein of wheat and percentage increase of the computed baking score due to bromate for the flours of this class was found to be:

$$r_{xy} = +0.56 \pm 0.118.$$

Although the number of cases under consideration is very small, this nevertheless lends some support to the observation made by Blish and Sandstedt (*3*) referred to earlier in this paper, to the effect that the degree of stimulation is roughly proportional to the protein content. However, this correlation is not sufficiently high, nor, in the present case, sufficiently significant, to warrant one attempting to predict with any accuracy from the protein content of the wheat the potential strength of a given flour of this class.

(3) Those showing no appreciable response. Such flours usually exhibit high baking quality by the basic procedure, and may be considered to have been developed to nearly the optimum point. The strong, high grade, bleached commercial flours in general belong to this class, but occasionally an experimentally milled, untreated flour shows this same characteristic of full development.

In view of the foregoing considerations, it is considered highly advisable to use the differential baking method when testing quality of wheat by the experimental milling and baking procedure.

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A METHOD OF HANDLING POLLEN OF THE APPLE AND OF THE PLUM FOR LONG DISTANCE SHIPMENT.

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Each year, beginning in 1922, the author has imported pollen for fruit breeding undertaken by the Department of Horticulture, University of Saskatchewan. During the first year of this period, only a small amount was obtained as only a few thousand crosses were made, but each year since then the importation of larger quantities has been necessary. This reached the maximum in 1927, when pollen was imported to make, in round numbers, 84,000 pollinations in the apple and 12,000 pollinations in the plum. The importation of this pollen has been necessitated by the nature of the breeding work undertaken and only through the ability to bring the required pollen long distances have the initiation and the continuance of this work been possible.

Early in the spring of 1922, arrangements were made to obtain apple and plum pollen for breeding work that season from the Division of Horticulture, Central Experimental Farm, Ottawa, Ontario; Department of Horticulture, Macdonald College, Quebec; Horticultural Experiment Station, Vineland Station, Ontario; Dominion Experimental Station, Summerland, B.C., and Dominion Experimental Station, Morden, Manitoba. In each case the selection of a method of preparing the material for shipment was left largely to the person in charge. Pollen of twelve varieties of the standard apple and of three varieties of the plum was obtained. In every case flowers in the unopened stages were sent and these were shipped on the twigs bearing them. The twigs bearing the flowers were wrapped in paper and the parcels were forwarded by mail. In four cases, the parcels were in the mail four to five days while in the fifth case, they were three days in transit.

Contrary to expectations, the material arrived in poor condition. When the shipments were received, all the flowers were open and the anthers showed discoloration. In many cases, the anthers were deep reddish brown in colour, while in a few cases the brownish discoloration was not marked. In the former cases, the anthers were a total loss and the flowers were discarded. In the latter cases, some of the anthers were of value and it was from these that the pollen used was obtained. The anthers showing the least injury were removed as soon as possible, placed in special small petri dishes and dried at room temperature. Germination tests were run on the pollen of the various samples obtained and those showing fair germination were employed in the breeding work. In general, the germination of the pollen varied inversely with the degree of browning in the anthers. The results obtained were very unsatisfactory, however, and it was decided before the season was over to throw into permanent discard this method of importing pollen.

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The following winter the possibility of importing pollen in the dry form was investigated. There appeared to be no obstacle in the way and the method gave promise of overcoming the difficulty experienced the previous year. It was decided, therefore, to give this method a trial, and it was considered advisable to obtain the pollen from one source only until a satisfactory method had been worked out. In view of the fact that the flowering season for fruits at the Summerland station occurred some time before the flowering season for the same fruits at Saskatoon, the coöperation of this station was solicited. This coöperation was promised on condition that full directions for preparing the pollen for shipment and containers for it be supplied.

Containers for the pollen to be supplied were prepared at Saskatoon, according to the plans made, a short time before shipment was to take place. Meyer's ointment box was considered a suitable container, and a supply of these was obtained for this purpose from a local druggist. This box is of tin and is supplied with a tightly fitting lid. The diameter of the one used was three inches and its depth one inch. Small weed seed vials were filled with dry calcium chloride and over each of their mouths were placed two or three thicknesses of cheese cotton. The cheese cotton used was sufficiently large to project well beyond the mouth of the vial and the edges of this material were tied securely to the neck with common wrapping cord. The screw caps were not replaced and the porous cotton covering permitted a free movement of air in and out of the vial. A vial thus prepared was placed in each ointment box together with a sheet of thin waxed paper folded to form a container for the pollen. After the lid of the box was replaced, the box was sealed with a strip of adhesive tape, three fourths of an inch in width, of the type used by nurses and surgeons. The sealed boxes, each with a vial containing calcium chloride and a sheet of waxed paper folded to serve as a container for the pollen, were then mailed to the Summerland station.

The method of preparing the pollen for shipment was similar to the method employed by fruit breeders and others in preparing pollen for use at home. A short time before the flowers were due to open and before the pollen grains were liberated, the anthers were removed. This was accomplished by removing the petals and then pinching off the anthers with a pair of tweezers. The anthers were then placed shallowly in open dishes and these dishes were placed in a warm room. Two or three days later, after the anthers had dried well and dehiscence had taken place, the boxes were opened and the entire mass of dry material was placed in the waxed paper folder provided as a container. The paper with its contents was then placed in the ointment box and the box containing the dry pollen and the vial of calcium chloride resealed with adhesive tape. These boxes with their contents were then shipped to the author at Saskatoon, a distance of nearly nine hundred miles over the shortest route. Pollen of four varieties of the apple—McIntosh, Wealthy, Duchess of Oldenburg and Yellow Transparent—comprised the first shipment.

About three weeks after its arrival, this pollen was used. Germination tests conducted at this time showed a high percentage of viable pollen grains and it was used on a long list of varieties of crabapples. Germination tests as late as the first week in July on pollen that was not used, and that was kept in the sealed containers, revealed fair viability even at that time. The success obtained from the use of this pollen in breeding work was all that could be desired and a good set of fruit was obtained.

So pleasing were the results obtained that it was decided to continue using this method. Each year since then pollen treated in this way has been imported in considerable quantities and used for breeding work. Plum pollen and some cherry pollen, too, prepared in the manner outlined for apple pollen, have been imported. Most of the pollen has come from the Summerland station, but small amounts have been obtained from the Vineland station. In every case, the pollen has arrived in excellent condition, and has given results that are highly satisfactory.

The method in use at the present time is virtually the same as that used during the season of 1923. Slight changes have been made in some of the minor details of the method outlined, but these were made only to increase the facility with which the work could be done. Waxed paper proved to be somewhat difficult to handle and "Onion Skin" paper is now being employed in its place in making the folders for the pollen. The removal of the anthers with tweezers proved to be a slow process when large quantities of pollen were required and a fine-toothed comb has been adopted as a substitute for the tweezers in performing this operation.

The method outlined could doubtless be used for many different kinds of pollen. The calcium chloride employed appears to possess the ability to maintain in sealed containers the dryness required for the preservation of pollen and this ability it retains for a long period in the ointment boxes used. After being in such boxes for one year, this agent was found to be in good condition and still able to take up large amounts of moisture. It is true that pollens differ greatly with respect to the length of the period during which viability is retained and that this is determined to a large extent by the inherent tendencies of the species, but in the majority of cases at least a dry atmosphere surrounding the pollen grains lengthens considerably the viable period. The method employed is practicable either on a small scale or on a large scale and if reasonable care is exercised in carrying out the details, the results obtained should meet the requirements of the most exacting plant breeder.

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BULB GROWING IN HOLLAND AND ITS RELATION TO DISEASE CONTROL.

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Under the regulations of the Destructive Insect and Pest Act, all nursery stock imported into Canada is subject to inspection by officers of the Dominion Department of Agriculture. In this work, the Division of Botany is responsible for the admittance or rejection of shipments that exhibit blemishes other than those caused by insects. The class of nursery stock most subject to diseases of bacterial and fungous origin is that of flowering bulbs and corms, and during the past five years studies have been made of these diseases to determine their causes and relative importance. The information thereby obtained is being used as a basis for the rejection or admission of affected shipments.

Soon after this work was started, it was found that imported gladiolus corms contained the greatest amount of disease. On investigation, these diseases proved to be of decided importance to Canada and were likely to become a limiting factor in the successful growing of this plant either under commercial culture or in the home gardens. A standard of freedom from disease for the admission of this stock was set, with the result that, during the past three years, a great many shipments of gladioli had to be refused admission.

Holland being the country exporting the large proportion of this stock to Canada, took up this matter with the Destructive Insect and Pest Act Board through their Consul General at Montreal. As an outcome of suggestions made to him by Mr. H. T. Güssow, Dominion Botanist, and transmitted to his government, an invitation was issued by the Netherlands Government to the Destructive Insect and Pest Act Board to send an experienced plant pathologist to Holland, at their expense, to spend the summer there to study their conditions of bulb culture and give every possible assistance in ridding their gladiolus cultures of disease. The writer was instructed to undertake this visit, and the observations recorded in this paper were made during a three months' study.

The bulb district proper is located in the province of North Holland principally, with a smaller area also in South Holland. It extends from Scheveningen on the coast, where small patches of bulbs may be seen, going north until it trails off at Alkmaar, a distance of approximately 40 miles. This strip of land lies just within the ridge of undulating dunes, which serve as the natural protection of the interior from the inroads of the North Sea; the two provinces are almost entirely below sea level. In the neighbourhood of Sassenheim, Lisse, and Hillegom, this strip of land is four to five miles wide and considerably narrower further north and south. Outside of this district, there are other sections where bulbs are grown fairly extensively, notably the drained areas or "polders" of Anna Paulowna

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A bulb house in Lisse.

and Enkhuizen in the north of North Holland and to a smaller extent in the province of Gelderland along the north bank of the river Rhine where bulb growing has taken the place of tobacco culture in some localities.

There is a certain amount of specialization in areas within the bulb district as regards the suitability of the soil for various kinds of bulbs. Although nearly all of the soil in the bulb district proper is pure sand, there are differences in depth, texture, the amount and size of the lime particles which it contains, and the nature of the subsoil, these conditions being essential to success in raising specialized crops. For this reason the Lisse-Hillegom district has become the centre of hyacinth culture, and the Sassenheim district the centre of narcissus culture. Tulips and gladioli are not so discriminating in their soil requirements, being grown successfully in the various types of sand and even in extremely heavy clays.

Viewed from the high land in the dunes, this flat, comparatively narrow strip of land unfolds a panorama of attractive and extensive gardens, which at blooming time must present a magnificent spectacle. The standard 105 centimeter-wide beds and foot-wide paths are laid out with mathematical precision, each field surrounded by 4 or 5 foot hedges of *Fagus, Ligustrum,* or *Crataegus,* utilized as wind breaks, and an extensive system of canals of varying widths bounding the fields and connected with one another.

By means of the canals and the carefully controlled drainage machinery, the level of the soil water is regulated with great precision at a distance of about two feet below the surface, each district having its own standard, compared with the standard at Amsterdam, known as the "Amsterdam Peil" or A.P. It occasionally happens that certain fields are not exactly at the right level, in relation to the standard water level of the district, for the best development of the bulbs grown in those fields. In these cases the tedious operation of removing the requisite amount of top soil by hand is undertaken so that the bulbs can make the best use of the sub-surface water.

Before dealing with the more detailed account of cultural methods in relation to the control of diseases I should like to describe briefly the existing organizations of the country as they apply to bulb growing. There are sev-

A general view of a bulb field, showing the canal and hedge which bound every field, the arrangement of beds and paths, and at the end of the field the areas infected with hyacinth yellow disease enclosed with sheets of "eterniet".

eral research and educational institutions dealing with the practical and research phases of bulb growing and plant pathology. The largest of these is the Landbouwhoog-school or Agricultural College at Wageningen in which a great deal of research on bulb growing is done in the plant physiological laboratory. Situated at this college is also the Phytopathological Institute composed of three sections; the Laboratory for Mycology and Potato Researches under Professor Dr. H. M. Quanjer, and the Laboratory for Entomology under Professor Dr. W. Roepke, both of which are in Wageningen, and one section in Lisse, the Laboratory for Bulb Research under Professor Dr. E. van Slogteren. These three men in turn annually are Directors of the Institute as a whole. Plant pathological and plant physiological researches and educational work are also conducted under the Universities of Utrecht, Leiden, Amsterdam and Gronigen. In connection with the first of these is the famous "Willie Commelin Scholten" plant pathological institution under Professor Johanna Westerdijk located at Baarn. In addition there are horticultural schools located in various districts which teach the practical phases of horticulture in which the various districts specialize.

The extension and inspection work is done by an organization directly under the Department of Internal Affairs and Agriculture and located at Wageningen, known as the Phytopathological Service under the direction of Ir. N. van Poeteren. This service is responsible for the answering of correspondence relative to plant pathological and entomological problems and other extension work, and for the inspection and certification of shipments of nursery stock for export.

The bulb growers themselves are organized into various societies, chief of which is the General Association for Bulb Culture with a membership of over 4000 and 38 locals in all the principal towns, with which is affiliated the Central Bulb Committee which is responsible for the collection of funds from the bulb growers on an acreage basis and its expenditure for purposes of research and advertising. Subsidiary to the General Association for

Bulb Culture are the Dutch Bulb Growers' Association, the Association of Bulb Exporters and the Associations for the Narcissus, Hyacinth, Tulip, and Gladiolus.

After being in Holland for a short time one cannot help being struck by the fact that of all the crop-raising industries, bulb growing is the most intricate and highly specialized, and in addition that the conditions existing in the country are peculiarly suitable for the successful production of this commodity at the lowest possible cost. Viewing the industry at the present time you note the result of many generations of training for this particular work, with the survival of those who have been successful not only because of good business methods and field management, but also due to a highly developed appreciation of the importance of diseases and the inclusion in the daily routine of measures directed at their control. You note the large acreages of deep well drained sandy soil with its slowly moving sub-surface water and adequate and cheap sources of cow manure, the pre-requisites for successful bulb growing. Together with this are the very moderate wages for skilled field labour unparalleled in this industry, and last but not least, the cheapest and most perfect facilities for transportation by water, in many cases directly connected with the packing sheds.

Transporting cases of bulbs by water directly from the packing sheds.

In order to stress the point of the complicated nature of this industry, let me say that even after several generations of experience and trial, the opinion prevails that it is still undergoing further stages of evolution, not only as far as disease control is concerned, but in field culture. One is struck by the variations of detail in this respect met with when visiting a number of establishments. Each one has some line of procedure which he thinks is more successful than the one employed by his neighbour, and even after all these years there prevails no standard of routine.

The following is a brief outline of the sequence of operations followed in Holland in the raising of bulbs, starting in the early spring and continuing to the time when field work ceases towards winter. Later under the headings of the four major bulb crops (hyacinth, narcissus, tulip, and gladiolus) the modified or additional cultural requirements relative to each

of these will be described, together with specific measures for the control of the diseases to which they are subject.

General Cultural Methods

In Holland it is seldom cold enough to freeze the soil after March 1, though slight night frosts may occur until May 15. All of the autumn-planted bulbs, including hyacinths, narcissus, tulips, etc., are covered with a mulch of dried reed (*Phragmites communis*) which grows profusely in the swampy waste lands. The thickness of the mulch depends upon the type of bulb to be covered, being quite heavy for hyacinths, less so for narcissus, and quite light for tulips. It serves the double purpose of protecting the bulbs from the injurious effects of alternate freezing and thawing of the soil, and of preventing the drifting of the light sandy soil by high winds.

About the end of February or the beginning of March the mulch is gradually removed. Liquid cow manure and sometimes a top dressing of ammonium nitrate is applied for the purpose of stimulating vegetative growth and for replacement of nitrogenous food material in the upper layers of soil which would have been leached out by the melting snow and spring rains. As soon as the soil is warm enough, rows of oats, peas, beans, lupines, or potatoes are planted in the paths between the beds as an additional precaution against the drifting of the soil.

Bulb fields extending up to the dunes, with a bulb house in the background, and in the foreground beds from which the bulbs have been dug, leaving the oat plants in the paths which will afterwards be placed on the surface of the soil when bulbs are replanted.

On the approach of warmer weather, when growth is very rapid, a systematic inspection of the fields is conducted by trained field employees, known as "disease-seekers", for the purpose indicated. These men devote their entire time to this work until the foliage begins to mature; on sunny days they use large sun shades in order to obtain a subdued light in which disease symptoms may be more readily detected. The diseases which they might expect to find during this search, and the field measures for their control in each case, will be described later when discussing individual bulb crops.

It is interesting to note that the sale of blooms is prohibited under the rules of the General Association for Bulb Culture, to prevent the glutting of the cut flower markets and the consequent reduction in the sale of the bulbs. The flowers are, however, all removed by cutting or stripping and taken away from the fields, usually by barges in the canals, being either placed in compost heaps or otherwise disposed of. It is essential to do this not only because of the weakening effect on the bulb of the setting of seed, but because the decay of the fallen petals between the plants provides a very suitable medium for the propagation of many of the *Botrytis* diseases.

The close planting of the bulbs, to be described later, practically precludes the possibility of using any implements for weeding except in the paths. Within the beds it is done by the workers by hand, the weeds being placed in baskets.

Towards the end of May, when the foliage of the early blooming varieties begins to mature, the digging of the bulbs commences. This is done by first cutting off the leaves with a dutch hoe and raking them up. The labourers then remove the bulbs, either with their hands or with the aid of flat short-handled trowels. The handling of the bulbs after they have been dug differs considerably according to the different kinds, and will be dealt with under the separate headings. Generally speaking the bulbs are placed in half-hectolitre (1½ bushels) baskets for transportation to the bulb house, which in the bulb district proper may be some distance away, for few, if any, of the growers have all their land in one place. There are growers in the more recently developed bulb growing districts, who own as much as 90 acres in one location and in some of these districts a light railway has been laid between all the fields. When the bulbs have been dug they are placed in trays which fit into tall racks on wheels and, when full, these can easily be pushed to the bulb houses; here, by means of a system of turn tables, they can finally be stored in any particular compartment of the bulb house desired.

After the bulbs have been cured, as described later, they are graded by hand or machinery into the following sizes:—

1. Mother bulbs for propagation purposes.
2. Saleable stock of different grades, some of it to be subjected to special treatment for early flowering.
3. The small or planting stock which has to be grown on before attaining saleable size.

As to field and bulb house inspections, other than the routine field examination by the disease-seekers already described, the Hyacinth and Narcissus Associations maintain specially trained field inspectors who visit all the fields of these bulbs during the growing season and keep extensive records of the area of each variety of hyacinth and narcissus under cultivation by every grower, and the presence or absence of disease in the varieties of each grower. These reports are of use in two ways: (1) a sale of hyacinth or narcissus bulbs can only be effected in auction or in private transaction in the bulb exchange by the grower being able to present a clean bill of health issued by the respective association; (2) these reports are also extremely

The process of "rigolen", or the deep turning of the soil by trenching.

useful to the inspectors of the phytopathological service who conduct the inspection in the bulb houses prior to shipment.

As soon as the bulbs have been dug, the preparation of the soil for the next year's crop is begun. Cow manure at the rate of 20 to 30 tons per acre is incorporated with the soil either by hand or machinery. A field the control of disease, the so called "Rigolen". The top 30 to 36 inches of the soil is turned upside down, that is, a trench of this depth is first excavated at one end of the field and is then filled by the complete turning over of the soil in an adjoining strip of the same width, thus producing a second trench, and so on down the field. This is done to every field on an average of once every three years and more frequently if soil-borne diseases have been found. During this process lime or chalk is often incorporated with the soil. The system of rotation adopted is also of importance from the standpoint of disease control. To illustrate the prevailing system of rotation, starting with virgin soil reclaimed from levelling the dunes to the point where the water level is at the most advantageous distance, the land is properly drained, thoroughly dug and cow manure incorporated; then as a rule some crop such as potatoes, peas, or beans may be planted and when they are harvested tulips are planted; when these are lifted the land is again heavily manured and dug, and hyacinths follow. After that the rotation is, usually, tulips, narcissus, hyacinths, but if the necessity arises two hyacinth crops may be grown two years running if the land has been trenched in between.

The bulbs are dug in the following order: hyacinths and tulips, followed by narcissi. They are planted in the reverse order, the narcissi being kept out of the ground as short a time as possible; the planting of these commencing about August 15th and the planting of the hyacinths extending till November 15th. The description of the treatment of the bulbs prior to planting will be reserved for the sections dealing with the four major bulb crops. In planting, the fields are laid out in beds 105 centimeters wide and 11 to 14 meters long, with one foot-wide paths; these paths run out at right angles from a central path 2½ to 3½ feet wide which goes lengthwise down

The reclamation of dune land for bulb culture. On the right, note the field now ready for use, part of it covered with farmyard manure.

the centre of the field. In the beds, the bulbs are planted in rows running the width of the beds, the number in the row varying from 7 to 11 depending on the size and kind of the bulb. The planting is done by hand, the bed being dug out 4 or 5 inches deep with a spade, the bulbs set and covered with soil dug out of the next bed to be planted; this operation proceeds down the beds on one side of the field and back on the other side, the bulbs in the last bed being covered with the soil removed from the first bed planted. The standard or area measurement is the so-called "Rijnlandische Roede," equivalent to about 144 square feet or 384 centimeters long of a 105 centimeter wide bed. A roede of large sized bulbs contains 320 to 400 bulbs. After the bulbs are planted the beds are covered with the mulch referred to previously, and this completes the outline of the year's routine.

Narcissus bulbs being planted. Note the bed on the right with the bulbs in position, and being covered with soil excavated from the next bed.

Hyacinth

It is important that the early development of the hyacinth shoots is retarded somewhat, so as to avoid a succulent growth which would be more liable to frost injury once the mulch is removed, and succumb more readily to attacks by bacteria and fungi. This initial retardation is accomplished by subjecting the bulbs to a period of heating before they are planted.

The diseases of this crop which can be detected by the trained disease-seekers are as follows:—

1. The yellow disease (*Pseudomonas Hyacinthi* Wakker).
2. The old or ring disease (*Tylenchus dipsaci* (Kühn) Bast.).
3. The so-called "Zwart snot" or black slime (*Sclerotinia bulborum* Wakker).
4. A leaf-destroying disease or "fire" caused by *Botrytis Hyacinthi* Westerdijk et v. Beyma Thoe Kingma.

Of these the most important at the present time is the yellow disease, which has been the cause of considerable loss during the past five years, but with the various treatments and preventive measures now in practice, it is being successfully controlled. When the typical water-soaked spots and decayed yellow streaks on the leaves are observed, glass or clay flower pots with no hole in the bottom are inverted over the affected plants and 10 per cent carbolineum, or 5 per cent formaldehyde, solution is sprayed on the surrounding plants in a circle of 4 or 5 feet in diameter, so as to destroy the foliage and check any possible spread of the disease which may have started. When a number of diseased plants are found in one portion of a field, this area is enclosed with sheets of an asbestos material known as "eterniet," each of which is one meter long and 65 centimeters wide, supported by stakes driven into the soil. This is done to prevent the spread of the disease by wind-borne bacteria and was found to be successful in experimental and field trials.

In the case of the "old disease" and the "black slime" both of which are soil-borne infections, an instrument known as a "snot koker", a cylindrical piece of iron 3 to 4 inches in diameter with a handle over the top, is used to remove the affected plants and the surrounding soil; if any number of affected plants are found in one spot, the soil is dug out for a depth of 18 inches in the area where the diseased plants occurred, and carted away. These two diseases are practically extinct in Holland at the present time; a few trenched areas were seen where some affected plants had been found, but no affected plants were left.

Botrytis Hyacinthi is often responsible for damage to the foliage, especially during prolonged damp weather. The fungus is apparently not carried by the bulbs and protective sprayings with Bordeaux mixture are employed, the frequency of these being based upon the disease-seekers' reports.

After the bulbs have been dug, they are taken to the bulb house for grading. Next they are placed in mesh wire-bottomed trays which are pushed into 5 foot wide racks extending almost to the ceiling of the store room. Some heat is then applied, enough to dry them quickly. Any further treatment depends upon which of the four following grades the stock is assigned to:

1. To be specially treated for early blooming, known as "prepared hyacinths."
2. For sale as ordinary flowering stock.
3. For use as mother bulbs for propagation purposes.
4. Small planting stock, to be grown on for another year or two.

The Bulb Research Laboratory at Lisse. In the foreground, a field with bulbs just planted and oat plants laid on the surface to keep the soil from drifting.

The so-called "preparing of the bulbs" is usually accomplished by raising the temperature of the particular storage room to 75° or 80°F. for two or three weeks during the period between the latter part of June and the first half of July. This stimulates the development of flower buds, causing them to bloom earlier when forced. To a limited extent, the preparation is also done by a patented process which consists of subsurface heating of the plants in the fields after they have flowered. A soil temperature of 80° to 85°F. is maintained by means of circulating hot water in pipes laid beneath the beds. Bulbs prepared in this way, after being dug and cured, can be sold as prepared hyacinths without further treatment. By this means it has been possible to obtain bloom as early as December 6th. The one bearing which preparation has to disease control is that bulbs slightly affected with the yellow disease, and thus having escaped detection in the field, will as a result of increased temperature, become obviously diseased since the causal organism is stimulated to increased vigour and any diseased bulbs will be eliminated.

In the inspection of hyacinths prior to shipment, particular attention is paid to the presence of the yellow disease. The procedure is to take representative samples from each variety and cut off the top of the neck of each bulb. By so doing, the presence of the disease may easily be ascertained by the discoloration of the cut scales and the yellowish ooze. The progress of this disease is downwards from the leaves into the bulbs; the presence of disease in the neck of the bulb can, therefore, always be determined.

The treatment of the mother bulbs for purposes of propagation has a very direct bearing on the control of the yellow disease. Two methods are in general use, known as "scoring" and "scooping." In the former, two or three cross cuts are made at the base of the bulb, and in the latter the

entire basal plate is scooped out with a curved knfe. These two processes stimulate the development of latent or adventitious buds which form a number of small bulbs on the cut surfaces. After the bulbs have been scored or scooped it is important to prevent the moulding of exposed tissue before this has dried and calloused over. This is accomplished in a number of ways, the most prevalent one being the covering of the cut surfaces with a thick lime paste. Towards the end of the storage period the scored and scooped bulbs are subjected to a temperature of 75° to 80° in order to stimulate the bulblet development; the temperature is then reduced for a few weeks before the mother bulb and its bulblets are planted.

Whether one or the other of these methods is employed depends upon the variety to some extent, but principally on the possible future market requirements, for scoring gives a smaller number but larger sized bulblets as compared to those obtained from scooping. Where yellows has been present, however, scooping offers a very successful means of eliminating diseased bulbs for the large amount of exposed tissue makes it possible to detect the presence of the disease easily and the bulb can be discarded and the knife disinfected. By the scoring method however, a diseased bulb is not detected and there is a danger that the knife which may have cut into a diseased bulb may be the means of spreading the contagion to others subsequently "scored".

The fourth group, which consists of the planting stock, after being stored in the bulb house, is subject to heat before being planted. The procedure recommended is to raise the temperature of the rooms gradually until during September it is maintained between 99° and 100°F. During October the temperature is gradually reduced to 80° to 85°F. and later heat is discontinued to accustom them to prevailing outdoor temperatures in November, in which month they are planted. It is an interesting fact that when hyacinth bulbs are heated soon after being dug, there is a stimulation of the bud development, with consequent earlier blooming, but when the heat is applied towards the end of the storage period it actually delays the development of the shoots when these bulbs are planted. Here, then, we get one of the reasons for the high temperature in September and the importance of this was referred to in the beginning of this section of the paper. In addition, a reason of even greater importance for the high temperature in September is the fact that this has proved to be a successful way of preventing the development of the yellow disease in plants grown from infected bulbs. The reason for this is not clearly understood, but it has been shown that the organisms present in the neck of a slightly infected bulb are the ones that are responsible for the primary infection of the shoot as it pushes its way upwards through the bulb in the early spring, and in some way the high temperature inactivates the organisms in this portion of the bulb.

Narcissus

In this crop, the disease-seekers pay particular attention to the detection of ring or eelworm disease caused by *Tylenchus dipsaci* (Kühn) Bast., and of a root rot, probably of fungus origin though hitherto none has been described. The eelworm has for years past been responsible for extensive losses, but

as a result of the research work by Dr. E. van Slogteren in perfecting the hot water treatment of bulbs, described later, and the widespread adoption of his recommendations, it was especially difficult last summer to find a single diseased plant. It is of great interest and significance to note that Dr. van Slogteren has established the fact that the eelworm which attacks the hyacinth is a different strain, or perhaps different species altogether, from that attacking the narcissus, cross inoculations failing to bring about infections either way. This point is of importance in the arranging of rotations in fields where the disease has occurred. Dr. van Slogteren's results are apparently widely accepted in Holland at least; indeed, so much do bulb growers believe in this investigation that they no longer hesitate to plant narcissi after hyacinth, a risk they could never afford to run, were it a fact that the eelworms of these two plants were identically the same species or race.

The stunting of the plants, slight yellowing of the leaves in streaks and the presence of small lumps in, or spicules on, the leaves, are the common symptoms in the field. When the disease-seeker finds a plant which he suspects is infected he removes the plant and surrounding soil with the "snot koker" and marks the spot with a stake. When, on more critical examination of the bulb of the suspected plant, the typical rings of discoloured scales are observed, thereby confirming the presence of eelworms, the soil and plants surrounding the location of the diseased plant are dug out to a depth of 18 inches to 2 feet in an area of about 2 square feet. Depending on the number of such infections occurring in a field the entire harvested crop is subjected to hot water treatment, the field is deeply dug, and not replanted with narcissi for several years.

Root rot occurs to a lesser extent in hyacinths also. It appears as patches in the field in which the plants die prematurely. The roots of these plants are brown or black and there are no symptoms on the bulbs. In the research work undertaken for the solution of this problem many different lines of investigation were followed. The result of the latest work indicates that it is caused by a soil-inhabiting fungus which has been isolated, though so far not named. In addition it was found that steam or formalin sterilization corrected this soil sickness. On the basis of these findings many growers are removing the soil of the affected areas to a depth of 1 foot to 18 inches, and replacing it with clean soil, but it is too soon to report on the success of this measure.

After being dug the bulbs are usually cured in the field in long rows, covered with a thin layer of soil, and left there until the roots can be removed easily. The soil is then taken off and the bulbs are left exposed for a time until they are thoroughly dry. They are then taken to the bulb house in slatted boxes, which are stacked outside and covered with portable roofs. They are then graded, the largest bulbs being kept for propagation purposes, the saleable sizes packed for shipment, and the planting stock made ready for planting, which commences as soon as the land is ready, usually early in September.

Propagation is effected by the production of "offsets" on the mother bulbs which are broken or cut off and grown on until they obtain saleable

size. The removal of these offsets has to be done with great care to avoid injury to their bases, especially in view of the fact that 6 or 8 varieties are subject to a basal decay caused by one or more species of *Fusaria*. This disease is being studied at the present time and it is doubtful whether the infection occurs in the field or after the bulbs have been dug.

The hot water treatment is given to bulbs which are suspected of containing eelworm infection, either in home grown stock or planting stock which is frequently imported from England. The basis of this treatment is the immersion of the bulbs in water which is kept at a constant temperature of 43.5°C. for 3 to 4 hours, depending upon the size of the bulbs. In giving this treatment the period allowed to elapse between the digging and treating is of importance, the period between August 18th and September 1st having been found to give the best results. Once the rudimentary roots appear, the treatment may result in considerable injury. Another factor in the success of this treatment is in the careful drying of the bulbs after they have been treated and the handling of the bulbs after they are dry and until they are planted. Briefly, the treatment is carried out by raising the temperature of water in round or rectangular tanks, by means of live steam or gas burners respectively. The bulbs are placed in open-meshed bags and lowered into the tanks. The temperature is then raised again to 43.5°C. and held there for 3 to 4 hours. In the case of the round tanks heated with live steam, the temperature of the water is maintained by manual control of the steam by valves, but in rectangular gas heated boilers a dual thermostatic control maintains a uniform temperature, the latter being on the whole the more satisfactory method. Some of the growers have their own boilers, but more frequently this work is done as a commercial venture, a moderate charge of 1.25 guilders (50 cents) being made per bag. One striking feature of this treatment is that the eelworms are not only killed in affected bulbs, but there is a decided increase in vigour of the plants grown from treated bulbs. So well is this feature recognized that in a few places visited they had their own boilers and all the planting stock was treated, even though it was known to be free from eelworm, at a temperature of 42°C., which is sufficient to stimulate the plants but insufficient for the killing of the eelworms; the temperature was raised to 43.5°C. when suspected stock was being treated.

Tulip

In the past tulips have not been subject to any disease as destructive as the yellow disease of hyacinth or the eelworm of narcissus, and the field and bulb house procedure does not differ materially from that outlined under general culture. Occasional outbreaks have occurred of the disease caused by *Rhizoctonia (Sclerotium) Tuliparum* (Kleb.) Whetzel, the fire disease caused by *Botrytis Tulipae* (Lib.) Hop. Of recent years a few cases of the so-called "new disease" have been observed, caused by an undescribed sclerotium-producing fungus. These are all soil-infesting organisms and the persistent use of the "snot koker" where diseased plants appear and the careful removal of fallen petals on the soil between the plants has kept these diseases well in check. No single diseased plant was observed during the frequent visits to tulip fields, which is confirmed by the fact that the percentage

of diseased bulbs found in shipments imported from Holland is exceedingly low.

It is of interest to note that tulips can be grown successfully in extremes of sand and clay as has been mentioned previously in the introduction. The so-called clay-grown tulips are much in demand by florists, for they claim that the flowers from such bulbs are of a richer colour. The seedsmen, however, who have to expose their stock for sale, prefer the sand-grown stock because the bulbs are cleaner and more attractive in appearance. The so called "virgin tulip", or one which has never borne a flower, can readily be distinguished from one which has bloomed, by the fact that in the former the papery scale is much darker in colour and is round, and further by the absence of the groove down one side which is caused by the pressure of the flower stalk against the side of the bulb.

At one plantation visited, there was a difference found in the method of setting the bulbs when they were being planted. Here, instead of placing them in the excavated bed with the base down and the nose upwards, the bulbs were laid on their sides, the advantage claimed being that by so doing it prevented the packing of the soil around the base of the bulb, thus allowing of more free root development.

The process of preparing tulips for early bloom is carried on to a very limited extent. It is never done in the bulb house, but by the method of underground heating already described for the hyacinth, either by subjecting the plants to the sub-surface heat and after the petals have fallen, or by using the beds in which hyacinths had been prepared in this way. The hyacinths are dug and then tulip bulbs are brought from other fields; these are laid on the hyacinth beds, covered with soil and subjected to the heat from pipes beneath for a week or more. Both of these processes have resulted in securing bloom before Christmas from the bulbs so treated.

Gladiolus

The culture of gladioli differs essentially from that of the bulbs already mentioned in that the corms are planted in spring between the third week of March and the middle of April. The digging of the corms is done in October, the corms being stored during the winter in the bulb houses at a temperature of 45° to 50° F. Otherwise the field routine is the same, with the exception of the measures which are definitely directed to the control of disease. I am under the impression that the diseases of this crop have not yet received the attention of research workers and growers of Holland, and this delayed action is reflected by the low standard, from the disease point of view, of gladioli imported into Canada.

As has been previously stated, the necessity of refusing admission into Canada to a large number of shipments of gladioli led to the visit during which these observations were made. A careful survey of the situation as far as gladioli are concerned led to the discovery of the following reasons why the diseases of the gladiolus had been neglected:—

1. The gladiolus culture in Holland as a whole constitutes an industry of minor economic importance as compared with that of hyacinths, narcissi and tulips.

2. Only a small proportion of the crop is grown by the large establishments, the exporter purchasing his stock of the cheap varieties from the large number of small growers scattered over the country.
3. The eradication of the diseases which were threatening the maintenance of the trade in the bulbs of greater money value has occupied the entire attention of the research men and growers.
4. The growers were trained in searching for disease symptoms in the field during the early stages in the growth of hyacinths, narcissi and tulips and when the gladioli appeared quite healthy at that time it was evidently concluded that the plants were sound and any signs of decline of the plants towards the end of the growing season were regarded merely as approaching maturity so familiar in the case of the foliage of the other bulbs. It is, however, a fact that the most important gladiolus diseases cannot be detected during the first 6 or 8 weeks of growth and that it is neither normal nor a sign of maturity to observe a yellowing and dying of the leaves towards the end of the season; these really constitute symptoms of disease.
5. As compared with most of the gladiolus-growing districts of Canada, the mean temperature during the summer in Holland is considerably lower. This results in an increased postponement of the incidence of the diseases and the reduction in the intensity of the attack. It appeared, however, that this natural advantage gained by the slower development of disease was largely offset by the length of the growing season, for not only are the corms planted a month earlier than they are in Canada but they are also harvested about a month later.

The attention of the plant pathologists and growers in Holland was directed to our own investigations in Canada, and the diseases as they appeared in the field were pointed out to them, thus enabling them to appreciate thoroughly not only the stand we had taken in demanding a certain standard of freedom from disease, but also the importance of eradicating these diseases from their cultures from a purely business point of view.

The diseases of the gladiolus in order of their importance in Holland are as follows:—

(1) The hard rot caused by *Septoria Gladioli* Pass.
(2) The dry rot caused by *Sclerotium Gladioli* Mass.
(3) The scab or neck rot caused by *Bacterium marginatum* McC.
(4) A neck rot and corm disease caused by an undescribed fungus of the *Botrytis* type.

A summary of the recommendations for the eradication of these diseases which were made to the growers visited and also in an address to the growers and exporters, is herewith given:—

1. The establishment of the system of disease-seeking, together with the methods of eradication as practised in the other bulbs.
2. The elimination of diseased material during the processes of digging, cleaning, sorting and packing.
3. The spraying of cormel and planting stocks with Bordeaux mixture for hard rot.

4. The destruction of the foliage by fire when the tops are cut off and the corms dug.
5. Avoiding for several years the use of land which has borne a diseased crop, and then only after it has been thoroughly turned by the method previously described.
6. The use of disinfectants for soaking healthy corms which have been in contact with diseased ones, and in the very expensive varieties after the corm lesions have been carefully cut out.
7. The digging of the corm at least a month earlier.
8. The organization of systematic field inspections by the Gladiolus Association with the consequent purchase of stock on the basis of the presentation of a clean bill of health, as is done in the case of the hyacinth and narcissus.
9. The more careful supervision of shipments for export.
10. The vigorous prosecution of a research programme by the institutions established for this work.

Acknowledgments

In closing I should like to express my sincere thanks to Professor Dr. E. van Slogteren and his staff at the Bulb Research Laboratory in Lisse, for the facilities placed at my disposal and their untiring efforts on my behalf in making my visit exceedingly interesting and profitable; also to Ir. N. van Poeteren, his staff at the Phytopathological Service and the many growers and exporters with whom I came in contact, for their kindly co-operation and interest.

THE PRINCIPLES OF COMPOUNDING MIXTURES OF GRASS AND CLOVER SEEDS*

A. Volkart†

In laying down principles for the compounding of grass and clover mixtures for a longer duration, it is necessary to bear in mind that in every mixture there exists a sharp competition between the different species. They compete with one another in taking possession of the space in and above the soil. As a result of this competition many plants are suppressed and succumb. A simple comparison between the number of seeds sown and the number of plants persisting per unit area shows that the percentage of surviving plants is very small. For instance, in a grass and clover mixture containing two kinds of clovers and seven kinds of grasses, we sow 800 clover seeds and 2450 grass seeds to the square yard, or 2 to 3 pure and viable seeds to the square inch. Actual counts of the number of plants established in the autumn of the year after seeding, and immediately before the first cutting during subsequent years, gave the following results per square yard:

	Number of Clover Plants	No. of Grass Plants	Total
First Year	498	1137	1635
Second Year	188	631	819
Third Year	17	128	145
Fourth Year	9	95	104

In other words, the gradual reduction in the number of plants during four successive years, as measured in percentages of pure and viable seeds sown, is as follows:

	First Year	Second Year	Third Year	Fourth Year
For Clovers	62	23	2	1
For Grasses	46	26	5	4
Combined	50	25	4	3

Figure No. 1 illustrates this condition graphically. The curve shows that this decrease is particularly noticeable during the first winter and from the second to the third year, when the development of the mixture reaches its peak.

This decrease is not distributed over all species proportionately, and consequently the different kinds of grasses and clovers are not found in the mixture in the same proportion as they were sown. In order to understand the principles underlying the successful establishment and management of mixtures it is essential to understand the reasons why some species disappear more quickly than others. The most obvious reason, of course, is unsuitability of soil and climate. This cannot be the only reason, however, since quite often certain kinds are able to establish a splendid stand if sown in pure culture, while failing in mixtures under identical soil and climatic conditions. Among other reasons responsible for the failure of certain species is the height of the plant. Low species are easily suppressed by high grow-

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ing plants if the mixture is not used as pasture and kept short by grazing. A well known example is white clover. It is very difficult for this plant to maintain itself in a mixture used for hay making. In the second year when the growth of the mixture is very vigorous it gets suppressed to such an extent that it does not recover. This was shown in many of our experiments, two of which are illustrated in Figure 2. The uninterrupted line shows the course of development of white clover in percentage of the total yield, measured in dry matter. Botanical analyses of 18 to 25 samples were made for each year and each experiment. In the second year both mixtures show a decline in the percentage of white clover, and thereafter a gradual increase. This increase cannot be due to the white clover sown. In each of the two experiments some check plots were left without seed of white clover. Nevertheless white clover developed also on these plots, as shown by the dotted lines. The reason for this is that under our conditions white clover seed not only is always found in the soil, but it also passes the digestive tract of animals undamaged and reaches the meadows in farm-yard manure and liquid manure. That it is wild white clover which develops in the later years of the mixtures is shown by the morphological features as well as by chemical analyses. Armstrong and Horton and subsequently Pethybridge and Ard have shown that English white clover is a cyanophoric plant while white clover from commercial seed originating in Eastern Europe is always acyanophoric, i.e., it does not develop hydrocyanic acid. We have found this to be true also for Swiss wild white clover and it can easily be shown that the white clover which develops in the grass and clover mixtures in the later years is cyanophoric. It therefore cannot be the white clover which has been sown, but must be wild white clover. Since this fact has been established we use only a small amount of white clover in the mixtures.

The same applies to perennial ryegrass. It is well-known that it is an excellent pasture grass in heavy, wet soil, but only where the winter is mild. For this reason it seems to be cultivated in North America only to a small extent. Climatic conditions such as in British Columbia would be very suitable for this grass. In mixtures which are cut for hay it is not able to develop to any great extent because it is a low grass overgrown by the high ones.

Similar again is the case of crested dogstail, sweet vernal grass, sheep's fescue, kidney vetch and other species. It would therefore be misleading to lay down as a principle for the establishment of mixtures that they must contain high grasses and low grasses in order that the aerial region be thoroughly utilized. In a normally developing mixture low grasses are always at a disadvantage and cannot develop satisfactorily.

Besides the low grasses there is another category of forage plants which are very often suppressed: the late species.

Amongst the different kinds of clovers the best example is alsike. If alsike is taken in a mixture together with an early red clover, it always is suppressed by the latter, because it develops more slowly. The more strongly red clover develops, the weaker remains alsike. Figure No. 3 illustrates this condition. Among the 20 plots in the foreground of the photograph,

which was taken in spring, 4 plots show off very sharply because they are backward in development. These plots were seeded with a mixture of late species only, namely alsike, bird's-foot trefoil and four late grasses. Between the plots seeded to early species only, and those seeded to mixtures containing both early and late species, there is no difference. The same fact is brought out strikingly in Figure No. 4. Each sheaf shows the yield of 5 square feet of mixtures containing (from left to right) early species, late species, and the two combined. The two sheaves in the centre contain only alsike and cooksfoot, two late species. The sheaves on the right originated from mixtures which contained the same percentage of these two kinds, but they were suppressed by the early species. Therefore they resemble much more closely the two sheaves to the left containing early species only.

The behaviour of alsike and early red clover in mixtures is illustrated in Figure No. 5. The upper row of graphs shows the yields of plots containing early species only, late species only and the two combined, respectively. The red clover used belonged to a number of different varieties of the perennial form, which showed marked differences in development. It is noteworthy that there is a very striking coördination in the respective development of red clover and alsike; in other words the less vigorous the growth of the red clover, the more strongly was alsike developed. The lower row of graphs shows the results of botanical analyses of sheaves. Here again the fact is strikingly brought out that alsike and late grasses are suppressed by the early kinds in the mixture, although developing very well when sown alone.

There are besides alsike a good many other species which are to be included among the late sorts of forage plants. Of the clovers we may add late flowering red clover, sainfoin and bird's foot trefoil; and of the grasses timothy, meadow fescue, red top, reed canary grass and, in many respects, cocksfoot. The rest of the clovers and grasses used for mixtures belong to the early sorts, so especially early red clover, alfalfa, which varies slightly in this respect according to the origin of production, yellow trefoil, tall oat grass, Italian ryegrass, yellow oat grass, meadow foxtail, crested dogstail, Kentucky blue grass and sweet vernal grass.

The difference between the early and the late species shows naturally most distinctly in regions where spring does not set in suddenly and the plants develop slowly. For that reason reference was made in my first lecture* to the slow rising of the temperature during spring in Switzerland as opposed to Canada. It is to be assumed that the difference between early and late species would not show as distinctly in the Prairie Provinces as it does with us in Europe and probably in British Columbia.

Of great importance is the degree to which these species are sociable. In this direction we have to differentiate between grasses and clovers which reach the highest point of their yielding power in the year after sowing and those which develop more slowly and give the highest yield in the third or fourth year. There are not only early species which give the highest

*See Sci. Agric. *9*: 7, pp. 434-447.

crop in the second year. Amongst the late species alsike, timothy and meadow fescue, also develop quickly if sown in pure culture. Clovers and grasses of this type owe their quick development to a speedy formation of roots. Therefore they do not easily agree with other species.

One of the grasses presenting difficulties in this respect under Swiss conditions is Italian ryegrass which develops so strongly, especially on good soil and after mild winters, that even red clover gets damaged. Tall oat grass also can thus increase to the detriment of all other species in the mixture. It is essential to know that these quickly developing species chiefly affect each other. If Italian ryegrass develops strongly the other quickly developing species are most affected, as for instance tall oat grass, but also the late species in this group such as timothy, alsike and meadow fescue.

As opposed to these quickly developing and often dominating species are those reaching the largest yield in the third or fourth years. These are not so sensitive. If other species dominate in the first years they allow themselves to be kept down only to develop the better when the dominating species fall back. Among these species, which are very valuable for our conditions, we count cocksfoot, yellow oat grass, crested dog's-tail, red fescue, Kentucky blue grass and bird's-foot trefoil. Especially the first two grasses are excellent in this respect and contribute a good deal to the high yield of the mixtures in later years.

In discussing principles for the compounding of mixtures we always have to keep in mind these ecological peculiarities which are of fundamental importance. These principles may best be discussed under two separate headings, viz., the choice of species, and the determination of the proportion of each kind chosen. Before discussing the selection of species in particular it may be well to emphasize that the proportion of clovers and grasses combined is also considered of great importance, and that it is considered a mistake to include too many species in a mixture.

Referring to the proportion of clovers and grasses we distinguish between the following classes of mixtures:

1. Clover and grass mixtures in which clover is prevalent; these are called "Kleegras".
2. Grass and clover mixtures, where grasses are prevalent, the most frequently used mixtures in alternate husbandry; these are our "Wechselwiesen".
3. Mixtures for permanent meadows, or "Dauerwiesen".

Clover and grass mixtures are made up mostly with one species of clover only. They are meant to apply to conditions which warrant a fairly certain growth of the clover and should be used for only a short period of years. The grass must therefore stand back. Its only purpose is to increase the value of the crop as cattle-food inasmuch as it prevents flatulency. If the clover is to be used several years the grass will prevent the field from becoming weedy. We advise using only a very small percentage of grass, especially if it is an early kind. In this way we combine:

95% early red clover with 5% Italian ryegrass.
80% alsike with 20% timothy.

95% alfalfa with 5% cocksfoot.
85% sainfoin with 15% tall oat grass.

The sowing of such mixtures is not very frequent. The farmers often prefer to sow pure clover on the assumption that grass damages the clover and lessens its good influence on the aftercrop.

Quite prevalent, on the contrary, are grass and clover mixtures, in which the grasses predominate. These formulae are for cropping during 4 to 7 years. For the grass and clover mixtures we recommend 30-40 per cent clovers and 60-70 per cent grasses; and for the permanent meadows only 20-30 per cent clovers and 70-80 per cent grasses. In these cases it is essential to give the grasses a good start, as they are expected to produce the larger part of the yield during the later years. Clovers have a better capacity for the appropriation of water and plant food and therefore can better be relied upon to develop well than the grasses. On the whole it is better not to include too many species in a mixture, because even though many of the minor species may develop slowly, still they hinder the maximum possible growth of the main components. This is borne out by an experiment made in 1922. Two mixtures were used, each containing 28 per cent clovers and 72 per cent grasses, the latter made up in one case of four, in the other of 12, species. The experiment was carried out in three different localities. Figure No. 6 illustrates the results obtained in two of these localities. It will be noted that the mixture with 4 grasses exceeds the one with 12 grasses in yield to the extent of from 4 to 16 per cent. On the average of four years the latter were inferior in Oerlikon by 8.6 per cent and in Kloten over a period of five years by 5.5 per cent. In the third experiment the mixture containing 12 grasses showed a higher yield in the third and fourth years because one or two of the principal species failed.

The results of these experiments are a warning against the use of too many species in a mixture. The inclination to make this mistake is often very pronounced, particularly on the part of seed merchants who favour long formulae on the assumption that even though three or four additional kinds would not improve the mixtures greatly, they would at least do no harm. The contrary is true; the skill of the farmer shows itself in a judicious choice of such clovers and grasses as are particularly suited to his conditions, and in composing his mixture of the right proportions of these kinds. In choosing the kinds, the following considerations must govern:

In the first place the *utilization of the mixture* has to be considered. If grazing is prevalent, especially during the later years of the mixture, we have to choose species which develop well in pastures, for instance perennial ryegrass (if the winter is not too severe and the snow does not last too long), then meadow fescue, crested dog's-tail and others. White clover will probably develop without sowing; it is to be sown only if this does not take place.

Secondly we have to consider the *duration of species*. In a mixture the different species must follow one another, one must step in the place of the other as soon as it begins to fail. With clover great stress must be laid on a permanent red clover, but it will always prove useful to take precautions for the later years. In this respect bird's-foot trefoil is especially suited for

mixtures even with early species. For mixtures with late species tall bird's-foot trefoil (*Lotus uliginosus*) might be chosen. Of the grasses cock's-foot is almost indispensible in this respect, be it for early or late mixtures. For later years yellow oat grass is also very suitable. It develops often only in the third and fourth year. Later still Kentucky blue grass, red fescue and reed canary grass become important. This succession is of great importance for the success of a mixture unless species of clovers and grasses can be used which take a leading position from the beginning and keep it until the end. Thus tall oat grass and meadow foxtail may dominate for five, six, and more years.

Thirdly we have to consider the *local climate and the soil* in selecting clovers and grasses to be sown. It is remarkable that the species which proved to be suitable for higher regions with us are those which have the widest distribution on the American Continent: alsike, timothy, meadow fescue, Kentucky blue grass and red top. Very well adapted for the higher regions are also meadow foxtail and reed canary grass, both of which require a soil with plenty of plant food and sufficient moisture. Perhaps this is the reason why they proved unsuitable under American conditions. On the other hand most of those grasses which dominate in the mixture in lower altitudes in Switzerland did not establish themselves in America save in a few exceptional cases. Thus little or no use is made here of tall oat grass, Italian ryegrass, perennial ryegrass, yellow oat grass. Tall oat grass and yellow oat grass are a little sensitive to grazing and besides are not winter-hardy enough. Perhaps they would be well adapted to the conditions of British Columbia if there should arise the necessity for sowing grass and clover mixtures for longer duration.

Concerning the soil most of the grasses show great ability to grow on a very wide range of soils. The need for lime or for alkaline reaction is not so great as in some kinds of clovers and if there are no capital faults (strong acidity, excess of water) unfavourable conditions in one direction can largely be balanced by favourable other properties.

A fourth point to be considered is *the form of tillering*. Often great importance is attached to the rule that a mixture of grasses and clovers should not only consist of species with dense tufted root stocks but also of species with runners in or above the soil. This point of view is now somewhat receding for the reason that there are no high growing grasses with quick development which produce runners. This is shown by an enumeration of the grasses with creeping root-stocks—Kentucky blue grass, smooth-stalked meadow grass, red fescue, reed canary grass, and perhaps also meadow foxtail which produces only very short runners. Only this latter grass is high and of fairly quick development. All others are either low or of slow growth. After all there should be no gaps in a properly made mixture and most of the tufted grasses are able to form an even and fairly dense turf. Lindhard in Denmark expressed the same opinion.

Fourthly, as mentioned before, we have to pay attention to the *height of the plants*. If the mixture is not pastured but is mainly cut for hay no purpose can be served by sowing low-growing species such as white clover,

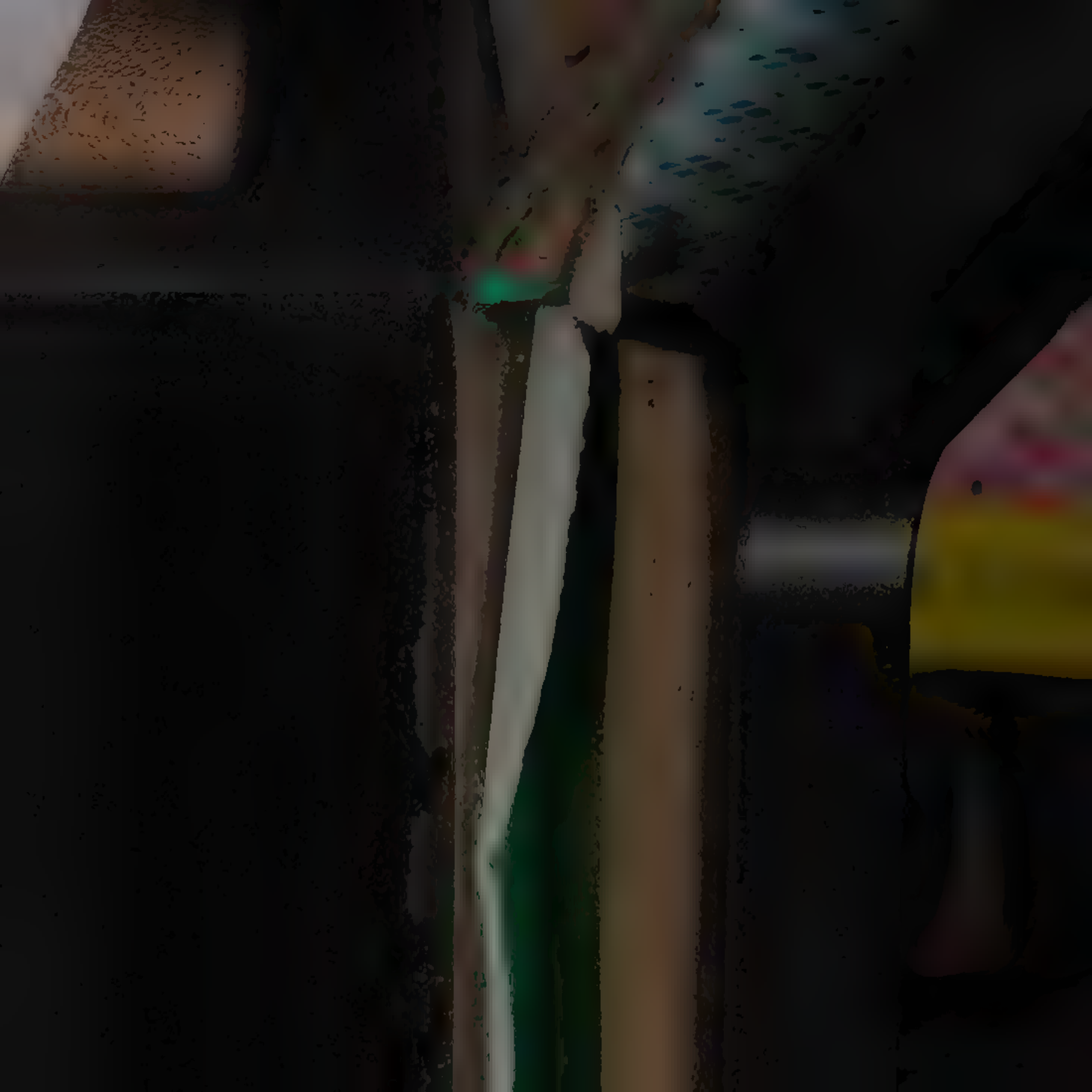
perennial ryegrass, crested dog's-tail. It is therefore not necessary to include so-called undergrasses in a mixture for mowing purposes.

Fifthly, great stress is to be laid on the distinction of *early and late species*. It should be recognized as a fundamental principle that theoretically a mixture should be composed either of early or of late species only. Mixtures composed of early red clover, yellow trefoil, tall oat grass, Italian ryegrass, yellow oat grass, meadow foxtail, Kentucky blue grass, on the one hand, and alsike or late flowering red clover, timothy, cock's-foot, meadow fescue, red top, on the other hand, would answer this principle best. However, such a puristic point of view can scarcely be carried through. Cock's-foot, for instance, cannot be missed either in early or in late mixtures. Further it will prove useful to include yellow oat grass in late mixtures. For reasons to be mentioned later it will moreover be prudent to take certain late species in a mixture consisting of early species, while always remembering at the same time that too many species have a tendency to reduce the yield.

A peculiarity which we dare not neglect in compounding a mixture is, sixthly, the *sociability*. Grasses like Italian ryegrass, which develop too much at the cost of other plants, disappear often very soon. They are better left out. We are here in a certain opposition to Stapledon, who regards this species as the pivotal species of all mixtures. Other clovers and grasses, under circumstances which are very favourable for them, can play a similar rôle to Italian ryegrass. Sociable clovers and grasses, on the contrary, are very valuable. They recede in the first years when high and quickly growing species develop strongly and take their place when they disappear. They have already been mentioned, and may be classed in order of merit as follows: cock's-foot, yellow oat grass, red fescue, Kentucky blue grass, and among the clovers bird's-foot trefoil.

A last point of view is the consideration of the species for their capability to keep alive in the first stages of development under unfavourable conditions. In Switzerland mixtures are very often sown in spelt as a nurse crop. When it is harvested clover and grass seedlings are very feebly developed. If dry weather follows the harvest the seedlings often die. Under such circumstances it has often been observed that contrary to expectations it is not species which usually are the dominating ones and of which one might presume that their root system would develop best, such as red clover, Italian ryegrass, tall oat grass, etc., which are able to resist. Much more resistance is shown by alsike, timothy and cock's-foot. It has been observed that these species do not spread their roots in the surface layers of the soil, but rather develop into depth. Thus it often happens that after a dry summer in the year of sowing alsike, timothy and cock's-foot form the principal components of mixtures; red clover, Italian ryegrass and tall oat grass are completely wanting. For this reason alsike and timothy are included in mixtures as an insurance even though normally they are suppressed by other kinds.

To sum up, the selection of species for a mixture depends upon the following points:



the grasses developed more strongly, so that red clover receded relatively and was only represented to the extent of 44.2, 52.9, 56.9 and 58.9 per cent of the total yield. In other words, the respective increases were only 8.7, 4.0 and 2.0 per cent respectively. In the following years irregularities set in, but the truly perennial character of this red clover is illustrated by the fact that in the fourth and fifth years it was still present to the extent of 31.2 and 26.8 per cent. Similar results were obtained in other experiments with red clover.

In the case of Italian ryegrass we have only the results of the second year available. To a basic mixture we added 2½, 5, 10, 15, 20, 30 and 40 per cent of this grass. The result is shown in Figure No. 8 in a very characteristic curve which illustrates that the proportionate decreases are even more considerable than in the case of red clover, i.e., for the increases in seed percentages from 10 to 20, 20 to 30, and 30 to 40, we have corresponding increases in plants of only 8, 5 and 3 per cent respectively.

Tall oat grass, as illustrated in Figure No. 9, shows a somewhat similar behaviour, although the differences are slightly irregular. This may be due to faulty sampling.

Cock's-foot, on the other hand, behaves in an entirely different manner. The curve reproduced in Figure No. 10 shows at a glance that cock's-foot is not a dominant grass. Evidently it is easily affected by other kinds, especially by red clover and tall oat grass. For this reason the differences between seed percent and yield percent in the first year are small and irregular, but become more apparent in the second and third year, after which the experiments unfortunately had to be discontinued.

Figure No. 11 shows that meadow foxtail is an early grass, as illustrated by the steeper course of the curve when compared with cock's-foot. The differences are very pronounced for the higher percentages, and remain evident for periods ranging up to ten years.

Similar experiments were made with a number of grasses and clovers. The results lead us to distinguish between two categories, the first including species which attain the culminating point of their development mostly in the year after sowing, and then go back more or less suddenly. With these species an increase of the percent sown from 10 to 20 produces a considerably higher percentage of plants of the species in the mixture, while further increases to 30 per cent and 40 per cent have but a small effect. In the third and fourth years the difference in the plots with higher percentages of seed have mostly disappeared. To this group belong the species which often dominate in mixtures such as early red clover, Italian ryegrass, tall oat grass, and even late ones such as alsike, timothy, meadow fescue and others. These late species have the same tendency to dominate provided they are not sown together with early species.

To the second category belong those species which even when sown pure only attain the culminating point in the third or fourth year. Such species also develop slowly in mixtures. The differences when sown in

different percentages are of greatest uniformity. They remain the same during several years and even accentuate in the course of time. Among these species we count cock's-foot, yellow oat grass, meadow foxtail, Kentucky blue grass, red fescue, and of the clovers, bird's-foot trefoil.

The conclusions for the practice of compounding mixtures are easily to be drawn. No purpose can be served by taking the species belonging to the first group in high percentages. On the contrary it will be necessary to cut them down to the utmost if they have a strong tendency to suppress the other components of a mixture, as is the case with Italian ryegrass.

This may be taken into account also for the late species, such as alsike, timothy, etc., although not so pronouncedly, as soon as they are sown under conditions which favour their development. The case is different when they are mixed with early species. Then larger percentages may be taken.

The species of the second group, however, may be applied in higher percentages. They will then develop better in the later years, when they are called upon to furnish the principal part of the yield.

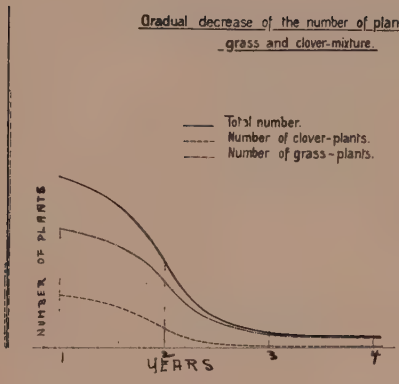
Summary

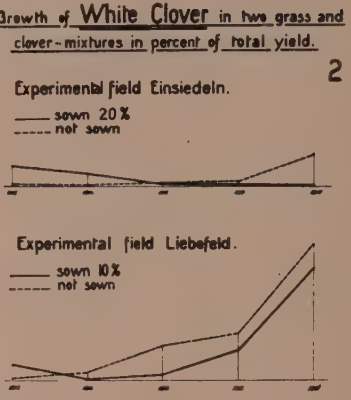
1. In selecting the species for a grass and clover mixture we have not only to consider the nature of soil and climate, the use to which the mixture is to be put and the manner of growth of the component grasses, but also the height of growth and the timely development of the different species are to be taken into account.

2. Low growing plants are only suitable for pastures. In mixtures to be cut for hay they get suppressed by the high growing species.

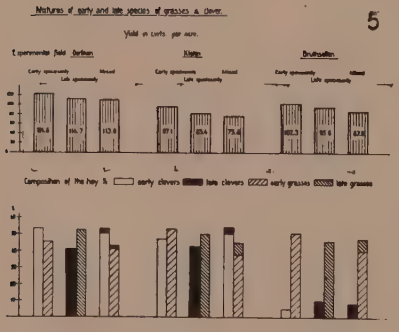
3. Taken as a whole it will be best to compound a mixture either with early or with late species of grasses and clovers only. In early mixtures it will be well to include such late species to take the place of the main components if these latter failed.

4. Early species with a tendency to dominate must be kept back. Therefore only small percentages of these species are used. This principle applies also to late species if they are inclined to over-rule the other components of a mixture under conditions especially favourable to them. Slowly developing species, on the contrary, must be taken into the seed mixtures in large percentages.


Gradual decrease of the number of plants in a grass and clover-mixture. No 1
Total number.
Number of clover-plants.
Number of grass-plants.
NUMBER OF PLANTS
1
2
3
4
YEARS


Growth of White Clover in two grass and clover-mixtures in percent of total yield.
2
Experimental field Einsiedeln.
sown 20 %
not sown
Experimental field Liebefeld.
sown 10 %
not sown

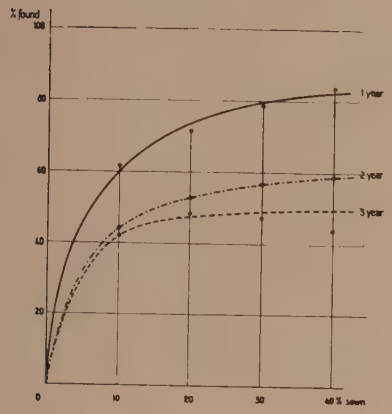
3


Mixtures of early and late species of grasses & clover.
5
Yield in cwts per acre.
Composition of the hay %
early clovers
late clovers
early grasses
late grasses

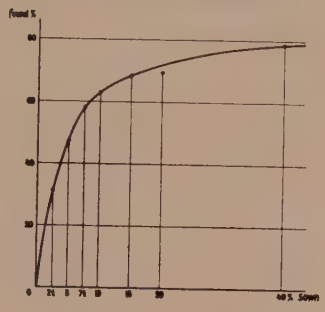
Yield in cwts of hay to the acre of two grass and clover-mixtures.
6
with 6 grasses
with 12 grasses
Experimental Field Oerlikon (fresh, clayey loam, pH 7.8)
1922
1923
1924
1925
1926
Experimental Field Kloten (rather dry, gravelly sandy loam, pH 7.6)

PLATE I.

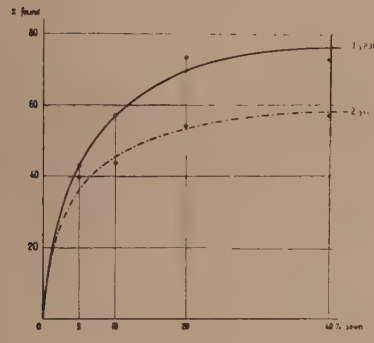
Percentage of Perennial Red Clover sown in a proportion of 10, 20, 30 & 40 % found in the hay of a clover and grass mixture in the first, second and third year (1913, 1914, 1915) 7



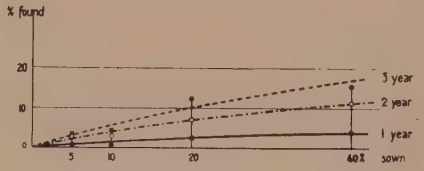
Percentage of Italian Ryegrass sown in a proportion of 2½, 5, 7½, 10, 15, 20 & 40 % found in grass- & clover mixture in the second year (1926). 8



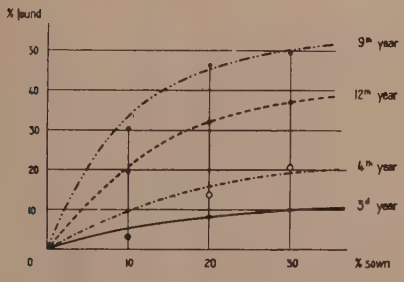
Percentage of Tall Oat Grass sown in a proportion of 5, 10, 20 & 40% found in the hay of a grass- and clovermixture in the first & second year 1909 & 1910. 9



Percentage of Cocksfoot sown in a proportion of 5, 10, 20 & 40% found in the hay of a grass and clover mixture in the first, second & third year (1909, 1910 1911) 10



Percentage of Meadow Foxtail sown in a proportion of 10, 20 & 30% found in the hay of a grass and clover mixture in the 3d, 4th, 9th & 12th year. (1914, 1915, 1920 & 1923.) 11



Suppression of Alsike by Early Red Clover in grass and clover mixtures. 12

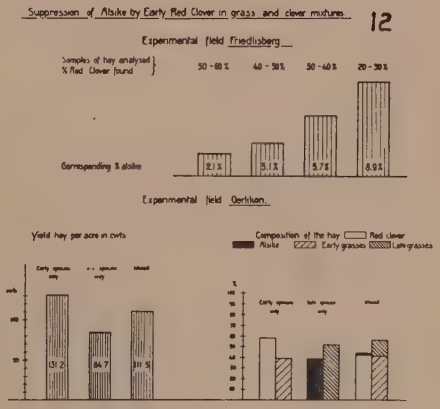


PLATE II.

THE DECOMPOSITION OF PEAT MEASURED BY CARBON DIOXIDE EVOLVED*

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[Received for publication January 18, 1929]

The object of this experiment was to ascertain whether the measurement of carbon dioxide evolved would be indicative of the fertility of sphagnum peat.

The peat that has been used throughout this part of the experiment was obtained from a recently drained bog situated along the Stony Plain road, about seven miles west of Edmonton. It is featured by a covering of sphagnum, intermingled with which is *Ledum groenlandicum* as the dominant shrubby ericaceous plant, and a sparse forest growth of *Larix* and *Picea* sp.

METHODS

The peat was air dried and ground by means of an ordinary meat grinder.

All the necessary constituents for the respective treatments, were first placed in a 500 cc. Erlenmeyer flask and then 25 grams of peat added. Where calcium carbonate was used the precaution was taken of leaving it in contact with the solution for a period of time before adding the peat, so as to obviate the danger of measuring the carbon dioxide evolved resulting from the reaction between the added chemical substances. Glass wool was inserted between the solution and peat; this necessitated the capillary movement of moisture and dissolved substances, and at the same time permitted an even distribution over the peat of the microörganisms contained in the inoculum. To the flask was fitted a rubber stopper through two holes in which glass tubes were inserted, one reaching to the bottom of the flask permitting the ingress of air, and the other just reaching below the stopper for the egress of carbon dioxide, a small plug of cotton wool being inserted in this tube to stop any small pieces of organic matter from passing out with the air current. The incubation flask was then connected to an absorption tower containing glass beads and 50 cc. normal .4 sodium hydroxide solution. The whole system, connected in series, was subjected to fifteen minutes aeration each day, immediately prior to titration; but the carbon dioxide evolved had free acesss to diffuse into the alkaline-absorbing medium at any time. The solution was changed and titrated each morning using standard hydrochloric acid, and indicators phenolphthalein and methyl orange.

Eighteen litres each of standard hydrochloric acid and sodium hydroxide solution, sufficient for the duration of the experiment, were made up. The former was protected against the ingress of ammonia fumes in the atmosphere, and the alkali solution protected by means of two soda lime tubes, one attached to a rubber bulb used for pumping air into the container and the other attached to the end of the 50 cc. pipette used for measuring the

*Part of Thesis submitted to the Committee on Graduate Studies, University of Alberta, May, 1928, in partial fulfilment of the requirement for the degree of Master of Science.

†Acknowledgement is made to Dr. F. A. Wyatt for suggestions and to Dr. J. D. Newton, under whose immediate direction the work was carried out.

alkaline absorbing solution, which was inserted through an aperture in the stopper of the demi-john.

In order to stop any back flow of carbon dioxide from the incubation chamber into the absorption tower next preceding it, a screw clamp was fixed on the rubber tubing connecting the absorption tower to the air ingress tube of the incubation chamber. This clamp was released immediately after the suction pump was started and the solution began to rise in the absorption tower.

The atmosphere drawn through the system was first washed by passing it through washing towers containing a 30 per cent potassium hydroxide solution, and at the other end of the system a similar tower was installed to wash any air passing back into the system when the suction was released.

(a) CHEMICAL.

Reducing sugars from straw. A mixture of 5 grams of Marquis wheat straw and 125 c.c. of a definite concentration of phosphoric acid were placed in a 250 c.c. Erlenmeyer flask, stoppered with cotton batting, allowed to stand overnight, and then subjected to steam pressure in the autoclave under the following conditions:

Sufficient heat was generated to raise the temperature in the autoclave to 120°c.c. in fifteen minutes, retention of this temperature for 75 minutes, and then the autoclave was exhausted in 10 minutes (*9*). The straw mixture was immediately filtered through a No. 40 Whatman filter and the filtrate analyzed by the Bertrand method for reducing sugars (*2*).

Total nitrogen was determined by Gunning's modification of the Kjeldahl method (*2*).

The determinations of carbon in peat were made by means of the "Liebig" combustion apparatus.

In all instances where numerous similar analyses necessitated the constant use of graduated apparatus, the same measuring instruments were used throughout the particular analysis. This safeguard is extremely necessary in such analyses as those of nitrate and sugar determinations, where so much mechanical manipulation forms a part of the methods.

(b) BIOLOGICAL.

Fixation of atmospheric nitrogen. A definite quantity (70 c.c.) of the straw filtrate was placed in an 800 c.c. Kjeldahl flask, inoculated with 10 c.c. of inoculum from previously isolated free nitrogen fixing organisms, and incubated for a definite time under laboratory temperatures.

RESULTS

Analyses of Peat Profile

In the reclamation of peat bogs drainage would be resorted to as a primary condition, which would mean that in the utility of the peat for agricultural purposes the "subsoil" or the mineral foundation upon which this vegetation is resting must play an important part along with the organic material in creating a suitable environment for microörganic activity, so it was thought desirable to make a profile of a typical section, take samples of each horizon, and analyze them for calcium, carbon, and nitrogen.

It is a well known fact that the organic matter of the mineral soil soon loses its definite plant structure, a reflection of decomposition, but that of peat is definite and discrete having all the earmarks of living vegetation.

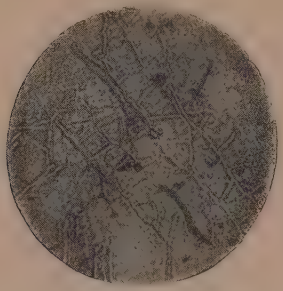

PLATE I. Photomicrograph of stainless preparation of organic matter from peat. Note definite structure. XI200.

It will be observed from Table 1 that there are three distinctive layers of organic matter, each conforming to a different carbon nitrogen ratio, not in the form of a smooth gradient from the surface to the interior as one might suppose, but rather presenting a condition that suggests we must look at some other factors in juxtaposition to the lowest layer of organic matter for an explanation of why such a relatively narrow carbon-nitrogen ratio at the extreme interior of the peat bed can exist. Bearing in mind the fact that we are dealing with a drained bog in which no gravitational water is present in the organic matter, there exists throughout the peat a free interchange of soil and atmospheric gases. This cannot explain the wide carbon-nitrogen ratio of the intermediate layer, but observation of the calcium content of the mineral subsoil suggests to the writer that the calcium of the layer adjacent to the lowest peat stratum has played an important part in furthering decomposition of that layer by neutralizing the acidic conditions therein and so creating a more favourable environment for biological activity. There is then the rather interesting fact which suggests that decomposition is taking place from opposite directions, a condition substantiated by the carbon nitrogen ratios of the different layers of organic matter. We see here the possible significance of the part that the mineral subsoil may play in a system to create a suitable environment for the growth of higher plants, and the position it must occupy in any consideration involving the fertility of our peat deposits.

Circumstances at the time of sampling were opposed to making a biological study of these different strata.

TABLE 1. *Analyses of peat profile.*

Vertical Formation	Depth	Carbon %	Nitrogen %	C/N	Calcium %	Water %
Fairly dark colour Partially decomposed peat	7" (0"-7")	43.4	1.31	1:33	.71	79.11
Light colour; raw peat.	4" (7"-11")	41.1	.95	1:43	1.22	90.96
Darker in colour than top layer.	12" (11"-23")	39.1	1.80	1:22	3.20	86.30
Sub-Soil (Gradation from granular structure to firm clay)						
Considerable dry material admixed	12" (23"-35")	—	0.11	—	.85	25.44
Trace of organic matter.	12" (35"-47")	—	0.05	—	2.35	24.63
No organic matter.	12" (47"-59")	—	0.02	—	3.25	20.28

Carbon was determined by the Liebig combustion method.
Moisture calculated on wet basis.

Is Nitrogen a Limiting Element?

The results of the experiment regarding the rate of nitrification of peat as well as the limited amount of nitrogen per gram of organic matter present compared to that in the organic matter of the mineral soils, indicated that nitrogenous substances were not readily available.* These conclusions were subsequently confirmed by the results of the carbon nitrogen analyses, which showed an extremely wide C/N ratio compared to mineral soils even where decomposition had been most active in peat.

From previous studies of the microbial population of peat it was observed that the dominant group was fungi, which, under suitable conditions, are very active in cellulose decomposition, but when the relatively enormous quantity of organic material per unit of peat soil is considered, the micro-organic numbers are small. The numbers are limited amongst other things by the unavailability of nitrogen; the addition of this element would stimulate physiological activity, which would be reflected in the decomposition of organic matter, with a consequent release of nitrogenous substances, which would, under suitable conditions, be metabolised into nitrate nitrogen for assimilation by vegetation.

Table 2. *Effect of dried blood upon numbers of microörganisms and accumulation of nitrate nitrogen, in eleven weeks.*

Soil	% Dried Blood Added	Nos. Microörganisms Millions / gms.	Mg. Nitrate Nitrogen per 100 gms. Peat
Sphagnum Peat	None (Control)	1.6	2.3
"	20.00	50.4	13.7

The percentage of nitrogen in the blood (11 per cent) together with that already contained in the peat compares favourably with the total nitrogen content of the organic matter present in 100 grams of either the Black Belt or Prairie soils.

This suggested that it would be necessary to add some form of easily decomposible nitrogenous material and it occurred to the writer that fixation of atmospheric nitrogen might be possible under certain conditions.

Fixation of Free Atmospheric Nitrogen in Solution

Our first concern then was to provide a suitable environment for the culture of free nitrogen-fixing organisms which had previously been isolated from the field immediately north of the Agricultural building. Ashby (*1*) found that dextrose provided an excellent source of energy for these bacteria, and as numerous experiments (*9*) have demonstrated the possibility of obtaining monosaccharides by hydrolysis of cellulose, a series of experiments were carried out with Marquis wheat straw and phosphoric acid, of variable concentrations, in an endeavour to obtain reducing sugars suitable as a source of energy for free nitrogen-fixing organisms. Observation of Table 3 shows that there was an increment in reducing sugars, expressed as dextrose, for each increase in the concentration of phosphoric acid.

Though these results were encouraging it was necessary to test the efficiency of the reducing sugars as a source of energy for the micro-organisms by inoculating with the specific bacteria a series of the respective sugar solutions and incubating for 32 days.

*Results reported in a previous paper by the author in Vol. IX, No. 6, p. 391, of this journal.

TABLE 3. *Reducing sugars in 100 grams Marquis wheat straw.*

Phosphoric acid (H_3PO_4)	Grams of reducing sugars per 100 gr. of straw.
%	%
0.00	3.12
0.45	3.60
1.00	4.05
2.00	5.07
3.00	5.28
4.00	5.47
5.00	5.68

Determination by Bertrand Method.

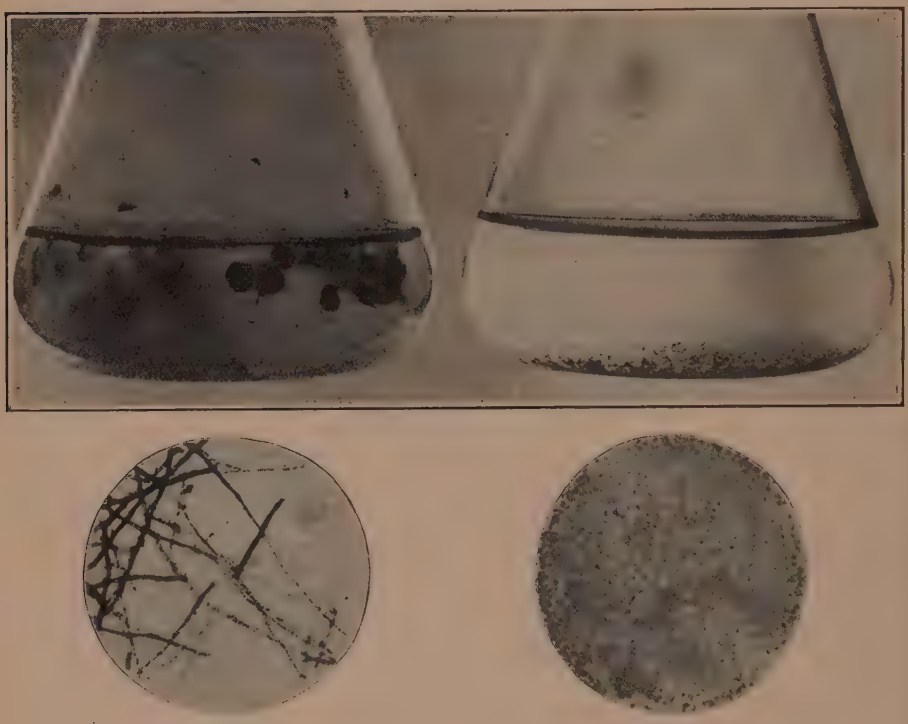

PLATE II. Isolation of atmospheric nitrogen fixing organisms. Top—Isolation of crude cultures in Dextrose-nutrient Salt Solution. The circular colonies shown were taken out of flask and slide—Lower left—Azotobacter made under sterile conditions. Lower right—A characteristic growth of Azotobacter. (Lower left and lower right photomicrograph magnification X1200.)

Three such series in all were carried out, but the result of the first prompted the utilization of the method and the subsequent two series were made as confirmatory tests of the initial one. Reference to Figure 1 indicates that free atmospheric nitrogen fixation was an accomplished fact, and steadily increased with each increment of reducing sugar corresponding to the increased percentage acid solution. It was not possible to analyze the solutions at the end of the incubation period and to calculate the relation between the sugar-energy metabolized and nitrogen fixed, but the significance of this biological phenomenon is that given available energy in the form of as-

similable carbohydrates and absence of nitrogenous material, free atmospheric nitrogen is fixed as cellular protein.

Evolution of Carbon Dioxide a Measure of Decomposition

Satisfied then that the straw filtrate contained the energy, and nitrogen fixation was an acomplished fact, the filtrate resulting from the 2 per cent acid hydrolysis of straw was introduced into the incubation chamber, and the main experiment commenced of measuring the carbon dioxide evolved daily over a period of two weeks.

In all instances where inorganic salts were added there was a marked increase of carbon dioxide over the control, and in cases where organic substances were added these increases were accentuated. This latter condition is not difficult to understand in the light of the fact that under normal conditions there is an unappreciable amount of easily assimilable food substances for microbial attack, but the addition of sugars furnishes available energy, the assimilation of which is reflected in increased amounts of carbon dioxide evolved.

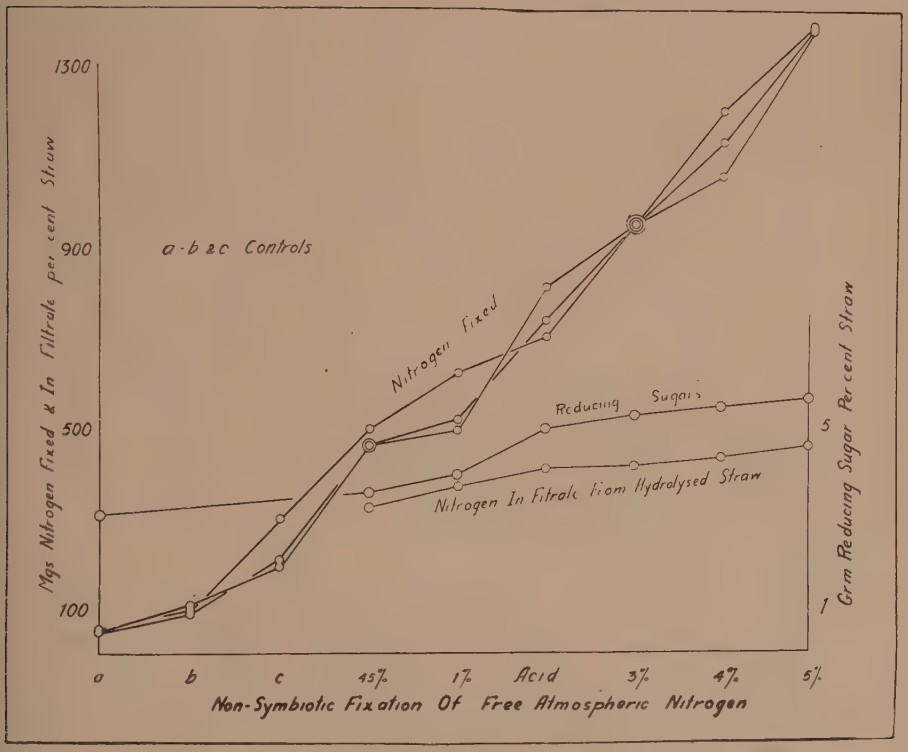

Figure 1.

Carbon Dioxide and Bacterial Numbers

It had been observed in the nitrification experiment previously reported in this journal (*3*) that there were conditions peculiar to biological activity. We saw, for instance, that there was a constant rhythm of bacterial numbers, and seeing that this condition reflects the expenditure of energy there

should be a fluctuating reflection in carbon dioxide evolution: a condition found by Russell and Appleyard (*8*).

From Figure 2 wherein a graphical representation of carbon dioxide evolved is made of the treatment giving maximum readings as against the control, it is apparent that the factor responsible moves in a definite cycle comparable to variations in bacterial numbers.

Granted then that carbon dioxide plays a primary part in soil economics, as an indicator of decomposition of organic matter, making soluble other essential substances as well as augmenting the atmospheric carbon dioxide, and so increasing photosynthesis (*6*) which, however, is limited by certain external factors (*4*), the fact must not be lost sight of that nitrate nitrogen must always be readily available, for in any process that is conditioned by several factors, the rate of growth is limited by the speed of the lowest one (*4*). Neither must we be blind to experimental facts which have shown that certain food substances, for instance carbohydrates and proteins, may be interchangeable for energy purposes, the decomposition of the nitrogenous material being at a minimum in the presence of easily assimilable carbohydrates. In these circumstances a high amount of carbon dioxide would be evolved and yet the soil remains infertile.

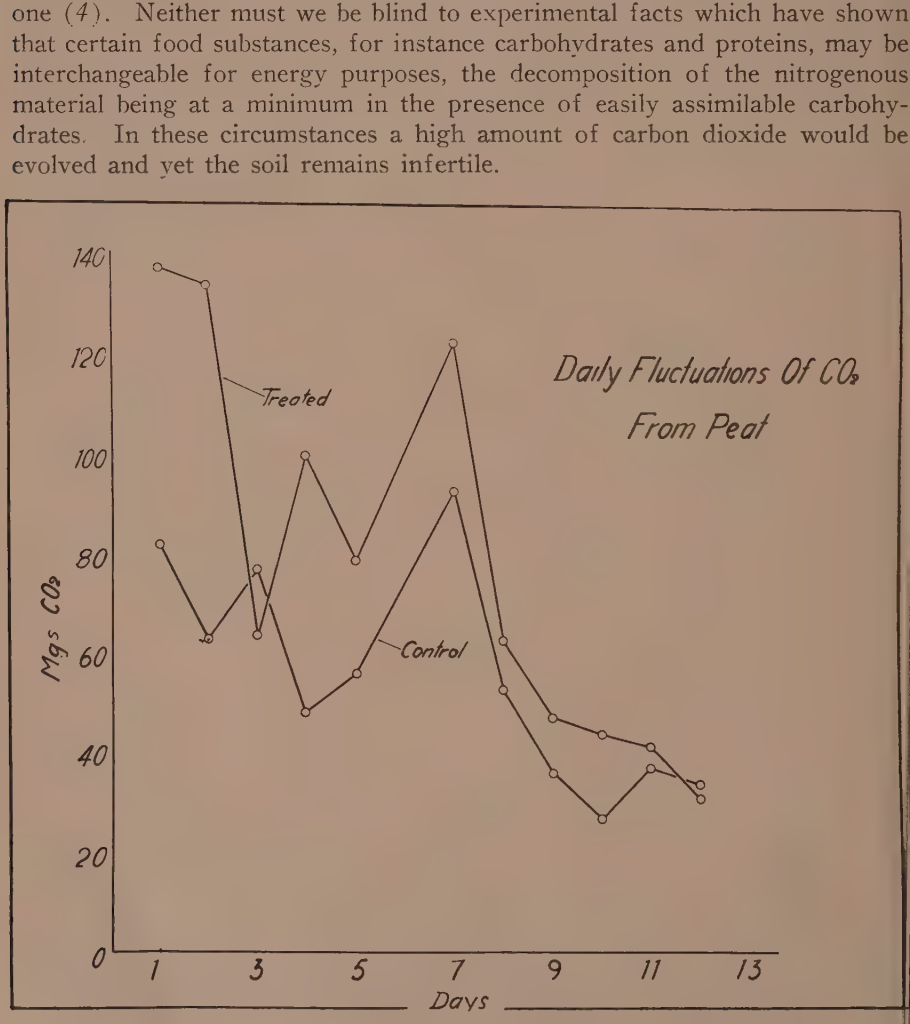

FIGURE 2.

Carbon Dioxide and Nitrate Nitrogen—Effect of Treatment

Reference to Table 4 shows the relation between carbon dioxide and nitrate nitrogen for the different treatments at the end of fourteen days. In the instance where the uninoculated sample receiving nutrient salts and calcium carbonate resulted in an appreciable increase of nitrate nitrogen, it will be observed that the total carbon dioxide evolved is less than in its inoculated counterpart, which also showed a much smaller accumulation of nitrate nitrogen (Table 4, columns 5 and 6).

The addition of straw filtrate resulted in a very marked increase in carbon dioxide and nitrate nitrogen over the control (Table 4, columns 11 and 12) but it must be observed that there is not any appreciable difference between the nitrate nitrogen of this, and that where nutrient salts and calcium carbonate were added, which condition emphasizes the fact that the ratio carbon dioxide nitrate nitrogen may be greatly displaced by the addition of an easily assimilable carbonaceous nutrient and yet not add to the soils' accumulation of plant nutrients. This condition suggests the importance of establishing a narrow carbon nitrogen ratio in peat, and any effort which tends to effect this is a step towards its fertility. This fact may not be apparent immediately, for the treatment of ammonium sulphate and calcium carbonate has resulted in no increase in nitrate accumulation (Table 4, columns 9 and 10), a result that is traceable to the microbial population peculiar to the peat under investigation. Any nitrate nitrogen formed, as well as the ammonia of the ammonium sulphate, may be utilized by the microorganisms, particularly the fungoid population, a condition emphasizing the active competition of microörganisms for plant nutrients.

Microörganisms of Peat and Reaction to Treatment

From our previous investigation of the biology of peat the evidence is convincing that the microbial population is wholly different, at least in the relative numbers of the different groups, to that of mineral soils. It will be observed, for instance (Plate III), that there is present a dominant fungoid population, which has a very wide range of adaptability to acidity, and because of the decidedly acid nature of peat it predominates.

In subsequent studies in which peat was made decidedly alkaline by the addition of potassium hydroxide there was fungous growth throughout the whole volume of the peat which was easily perceptible to the naked eye.

Fungi of the soil can asimilate various carbohydrates and most species can obtain their energy from cellulose, in which respect they differ from many bacteria (7) and, on the other hand, they can readily assimilate ammonia and nitrates, but have no power to oxidize ammonia to nitrates (7). It is not difficult to see then why the addition of ammonium sulphate had no effect on nitrate production during the time of the experiment, but it must ultimately tend to narrow the C/N ratio of the organic matter by becoming incorporated as microbial protoplasm.

The fixation of free atmospheric nitrogen by mixed cultures of the specific organisms in the filtrate treatment could not be definitely established owing to the short duration of the experiment, but the increase is suggestive, although not necessarily significant owing to the complexity of the organic

	CONTROL	TREATED SAMPLE
Total nitrogen	.8%	.87%

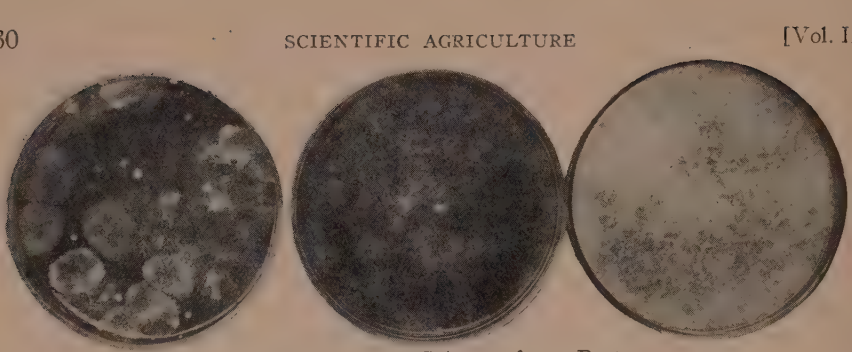

PLATE III. Plate Cultures from Peat.
Left—Total bacterial counts ..... pH 7.0
Centre—Actinomyces ..... " 5.9
Right—Fungi ..... " 4.0

material with which we are dealing. A qualitative test for nitrogen fixing organisms showed their presence in all the incubated samples excepting the control.

From our previous discussion it is obvious that in peat soil we have to contend with a microbial population which consists mainly of fungi, and the question naturally arises, has the addition of the various chemical substances had any influence on the dominacy of the microörganic groups? To answer this question all the different treatments were plated out in triplicate on specific media for the isolation of (a) bacteria, (b) fungi, and (c) actinomyces; and, in no instance, was there any change in the numbers or groupings from that of the control; which leads the writer to suggest that although nitrate accumulation was an established fact in one or two cases, it would not necessarily be permanent but rather transitory, owing to the addition of substances which initially displaced that biological condition which reflects the history of a very stable environment, and that sooner or later competition for nitrate nitrogen would set in between microörganic and plant growth. It is an established fact that nitrates accumulate, and later disappear, when peat is treated with calcium carbonate (7), a condition also confirmed in our own experiment.

TABLE 4. *Peat under different chemical treatments: carbon dioxide evolved and nitrate nitrogen accumulated in 14 days, from 25 grams of peat.*

	Control		$CaCO_3$		$CaCO_3$ Nutrient Salts		Nutrient Salts		$CaCO_3$ & $(NH)_4SO_4$		Straw Filtrate		Carbohyd (Starch a Diastas	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Carbon Dioxide mg.	595	703	732	711	662	789	755	778	648	751	1074	1034	863	82
Parts per Million $NO_3 - N_2$	36	35	40	39	45	37	33	35	36	31	47	47	33	3

Odd numbered samples uninoculated.
Even numbered samples inoculated with mixed cultures of free nitrogen fixing organisms.

Carbon Dioxide as a Measure of Fertility

In mineral soils the measure of carbon dioxide may be used in grading their fertility (*10*), and although in peat we are dealing with an abnormal plant environment, it was thought desirable to test out the practicability of the method in respect to the sample which had been modified by the addition of the simple carbohydrate resulting from the treated straw.

Definite quantities of peat (200 grams) were weighed into earthenware crocks, the necessary constituent added, and in each was planted a dozen Victory oat seeds. The crocks were placed in the greenhouse and subjected to controlled conditions as regards temperature, light and water. Germination was even and rapid in each container, but in a very short time a variation became apparent, probably immediately after the seed had become exhausted of food (Plate IV). Nos 1 and 5 showed very little growth, the culms remained spindly and the colour of the vegetation indicated a lack of nitrogen. The remainder showed progressive growth, but Nos. 3 and 4 gradually exceeded No. 2, and the colour of the formers' vegetation was analogous to vegetation growing in a normal habitat; but it soon became evident that there was some condition interfering with the normal plant metabolism of Nos. 3 and 4, for the tips of the plants began to fade from the apex down, which condition suggests a lack of potassium, a condition which is prevalent in some of the muskegs of the United States (5).

It is interesting to note that as a result of our preliminary investigation of the decomposition of peat by the carbon dioxide method, there is indicated an apparent lack of potassium, a condition of which we had previously no evidence.

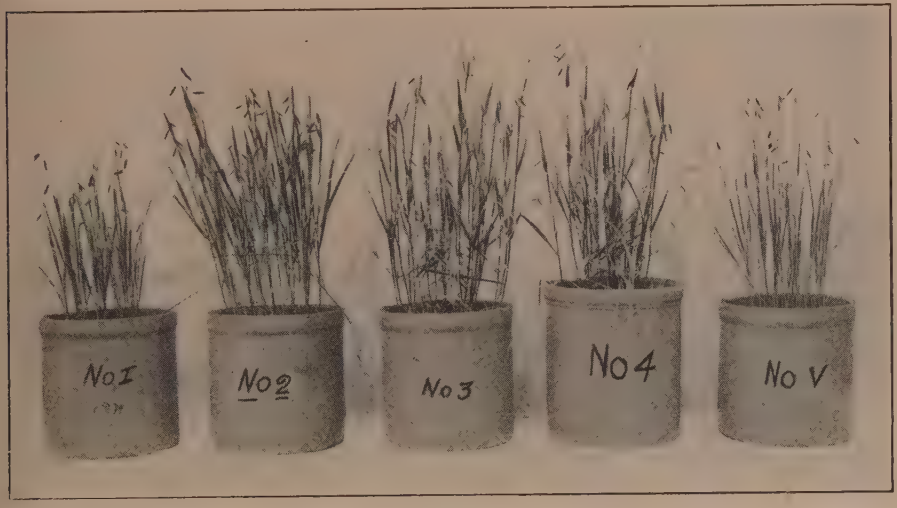

Plate IV.

No. 1—Control. No. 5—Nutrient solution. No. 2—+$CaCO_3$.

Nos. 3 and 4—Filtrate from hydrolysed straw + $CaCO_3$ + nutrient solution.

Photo does not show distinguishing colours of vegetation. Nos. 1, 2 and 5 are very light, but Nos. 3 and 4 are quite normal except that numerous leaves have died back from the tips and others are becoming mottled from apex downwards. If this had not occurred vegetation in Nos. 3 and 4 would have been very profuse as compared with the others; the culms are also much thicker and stronger and the leaves broader than No. 2.

SUMMARY

1. Analysis of a sphagnum peat profile has been made.
2. Experimental evidence suggests that nitrogen is a limiting factor.
3. Daily fluctuations in carbon dioxide evolved are analogous to known fluctuations of bacterial numbers.
4. A fungoid population is characteristic of sphagnum peat.
5. The carbon dioxide evolved cannot be used alone as an idex of fertility when applied to peat soils.
6. Potassium is probably a limiting factor in plant nutrition.

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BOOK REVIEW

LABORATORY MANUAL OF GENERAL MICROBIOLOGY. By E. B. Fred and S. A. Waksman. (McGraw-Hill Book Co., New York, 1928. Pp. 145, fig. 19. Price $2.00).

This book represents a well arranged laboratory guide designed particularly for students working in soil microbiology who have already had some practical experience in general bacteriology.

In Part I, 46 pages are devoted to the subject of culture media. Following general directions for their preparation are recipes for making some 111 different media for the cultivation of bacteria, fungi, yeasts, actinomyces, protozoa and algae. The authors appear to have made a good choice, and have included in their selection many up-to-date formulae not hitherto assembled under one cover.

Part II deals very briefly, in 5 pages, with staining methods, while Part III treats, in 32 pages, of qualitative and quantitative methods of analysis for the examination of soils and the changes produced in them by microörganisms.

The final section of the book, Part IV, some 51 pages in extent, consists of practical class exercises designed to embrace a general survey of the soil population. In these exercises emphasis is rightly laid on the quantitative aspects of the different soil phenomena, and a well-coördinated practical outline is the result. This section also includes some useful illustrations and text-figures.

Although the student in general would appear to be already well provided with a choice of laboratory guides to general bacteriology, yet this new work will doubtless be found to be most useful, particularly for those interested in the study of soil bacteria and allied organisms.—A G.L.

SMOOTHNESS OF AWN IN WHEAT*

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[Received for publication February 5, 1929]

According to Harlan (*1*) smooth-awned barleys have existed for a long time in Russia and in Asia Minor, but after searching available literature no record was found of a high degree of smoothness of awn in wheat. Percival (*2*) in discussing the scabridity of *T. durums* says, "they are almost smooth near the base, thus differing from those of *T. turgidum* which are usually scabrid throughout their whole length."

Percival has recently supplied the writer with some heads of *T. durum hordeiforme* Host. Upon microscopic examination it was found that the awn near the base was almost glabrous. The remainder of the awn had relatively short barbs. The awns, however, were rougher and different from those described below.

Origin

During the summer of 1928 the writer found in row S-24-60 E_3 in the wheat nursery several plants which felt smooth when drawn between the finger and thumb. This row descended from a strain supplied by Dr. H. K. Hayes in 1922 under the number II-15-55 which was from a Marquis x Iumillo cross made in 1915. The treatment between the time of introduction in 1922 and the time of finding the comparatively smooth-awned plants in 1928 is given in Table 1.

Table 1.

1922-24	1925 Head Row	1926 Head Row	1927 Head Row	1928 Bulk Seed
II-15-55	S-24-60	S-26-60 E	S-24-60 E_3	S-24-60 E_3

The original stem variety produced awnless plants *vulgare*-like in appearance but was apparently heterozygous for certain morphological characters. The original head S-24-60, selected in 1924, had awns about 2½ inches long and hard (not brittle), red, ovate kernels. This head produced in 1925 segregating progeny for length and colour of awn and one awnless plant with short apical awns. Since baldness is dominant to beardedness, the awnless plant may have resulted from a natural cross in 1924. The progeny of this head, designated as S-24-60 E, gave both awned and awnless plants in 1926, some of which were quite durum-like in appearance. From this progeny, a single head selection S-24-60 E_3 bred true for the bearded character in 1927, though there was considerable variation in length and colour of awn. The kernels were amber in colour and durum-like in texture. The progeny of the head row in 1927 was harvested in bulk and grown in 1928, when for the first time, plants which appeared to be smooth-awned were noticed.

Description

Out of approximately 400 plants in the row the majority had rough awns. About 40 were found which exhibited a high degree of smoothness

*Read at the annual meeting of the Western Canadian Society of Agronomy, Saskatoon, Sask., December, 1928.

†Assistant Superintendent in charge of cereals.

‡The writer is indebted to Mr. A. T. Elders, Agrostologist, Brandon Experimental Farm, for micro-photographs taken and for other valuable assistance rendered.

of awn while others appeared to be intermediate in scabridity of awn. The awns from the rough-awned plants were compared under the microscope with those from the smoother awned ones. The rough awns appear cylindrical from their beaked tip to the base and have long pointed barbs over the entire length. (See Figure 2). The plants with the smoothest awn are also cylindrical from the beaked tip to the base but have a few scattered barbs, short and blunt on the upper three-fourths of the awn. Equally as many barbs were noticed near the base as on the rougher awns but the barbs were short and blunt and entirely different from the barbs examined on the rougher awns (see Figure 3).

The data presented above would indicate that a mutation had occurred producing awns in wheat with a high degree of smoothness.

Economic Importance

Rough-awned wheats are rather disagreeable to handle and may become a source of danger to certain kinds of live stock, since a portion of the rough awn may easily become buried in the throat tissues of the animals. The creation of a smooth-awned variety of wheat, equal in agronomic value to the rough-awned varieties, would therefore be of considerable practical importance. This may possibly be accomplished by hybridization. It is the intention of the writer to cross this wheat with some of the commercial varieties in an attempt to produce a smooth-awned wheat of economic importance and incidentally to study the genetics of barbing of awn.

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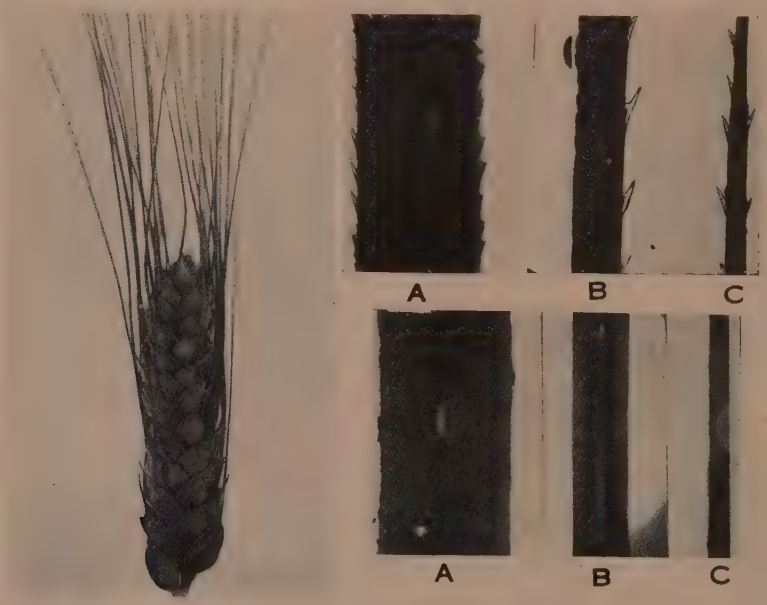


Plate I.
Left—Fig. 1. A typical smooth-awned head.
Upper right—Fig. 2. Rough awn. A—base; B—centre; C—tip.
Lower right—Fig. 3. Smooth awn. A—base; B—centre; C—tip.

"LEBETON"
SON EMPLOI RAISONNE DANS LES CONSTRUCTIONS RURALES

FERNAND CORMINBOEUF
Gravelbourg, Sask.

Avant d'aborder la partie technique qui formera la substance de ce travail, faisons connaissance intime avec notre ami le "Béton", ce dévoué serviteur de l'industrie et de l'agriculture. Il résultera de cela, une meilleure intelligence des faits qui vont suivre. Sa connaissance intime est étroitement liée à l'étude de sa nature, résultante qualitative des propriétés de ses propres constituants.

ETUDE DE SES CONSTITUANTS PHYSIQUES

Le béton est un mélange en proportions variables de petits et de gros agrégats lesquels sont liés ensemble par une pâte de ciment. Disons le tout de suite, le petit agrégat peut être constitué par du sable et des criblures de pierres, et le gros agrégat par du gravier, de la pierre concassée, ou encore du laitier de hauts fourneaux broyé.

Le Ciment.

Il est généralement bien connu. En effet, rares sont les personnes qui ignorent sa composition et sa fabrication.

L'histoire de sa découverte et son évolution à travers les âges sont toutefois moins connus. Les Romains déjà utilisaient le ciment; les fondations du Forum de Rome sont faites de couches alternantes de béton et de pierres. Ceci nous révèle une divergence d'opinion chez les maçons de l'Ancienne Rome, car quelques-uns utilisaient de gros agrégats mélangés au ciment, et les autres se contentaient de lier les pierres par une pâte de ciment.

Malgré leur méthode peu scientifique de fabriquer le ciment (car on pense qu'ils tiraient les matières premières du marbre ou des cendres volcaniques et qu'ils utilisaient l'énergie calorifique des volcans pour leur transformation), les Anciens Romains ont construit des édifices qui sont encore aujourd'hui des monuments de solidité. Ces édifices sont naturellement très massifs car on n'avait alors aucune notion du béton armé.

Après la chute de l'Empire Romain, l'usage du ciment disparait et il faut attendre jusqu'au milieu du 18ème siècle pour voir sa réapparition avec John Smeaton.

Il réussit, en 1756, à fabriquer un ciment hydraulique qui fut employé dans les fondations du phare d'Edystone, en Angleterre. Le ciment obtenu par sa méthode maintes fois modifiée subsista jusqu'en 1824.

A cette époque, Joseph Aspdin, maçon de Leeds, découvre la fabrication d'un produit connu décormais sous le nom de Ciment Portland, nommé ainsi en vertu de l'analogie de couleur qu'il présente avec la pierre de l'île Portland, utilisée dans la construction de l'Abbaye de Westminster, où fut inaugurée l'emploi de ce ciment.

Le ciment employé aujourd'hui peut être défini ainsi "Poudre finement pulvérisée, composée dans des proportions définies de chaux (CaO), de silice (SiO_2) et d'alumine (Al_2O_3). Il contient aussi, mais en petite quantité, des oxydes de fer, de magésium, de sodium et potassium.

Ces particules sont d'une ténuité remarquable, puisqu'elles ne sont pas retenues par un tamis de 200 mailles au pouce linéaire, alors qu'un tamis de cet ordre de grandeur retient l'eau.

Sa Fabrication et sa Composition. Jetons un rapide coup d'oeil sur les diverses étapes de sa fabrication. Nous avons au début, du calcaire ($Ca\ Co_3$) et de l'argile ($Al_2\ Si_2\ O_7.2H_2O$). Ces produits bruts sont broyés, finement pulvérisés, puis mélangés dans des proportions bien définies. Nous voici en présence de la troisième étape; elle est de beaucoup à la fois la plus importante et le plus intéressante des opérations. Le mélange des produits dans des fours rotatifs est soumis à une température de 2600 à 3000 degrés F. Le combustible employé est ordinairement l'huile ou la poussière de charbon dont on active la combustion par un système de souffleries. Sous l'influence de ces hautes températures le calcaire est décarbonaté et l'argile déshydratée, suivant les équations:

$$Ca\ CO_3 = CaO + CO_2$$
$$Al_2\ Si_2\ O_7.2\ H_2O = Al_2\ Si_2\ O_7 + 2H_2O.$$

Le produit issu de cette transformation sort sous forme de mâchefer dont les morceaux sont à peu près de la grosseur d'un oeuf. Ce mâchefer est broyé et pulvérisé progressivement. Ceci constitue un ciment qui a la propriété de faire prise immédiate au contact de l'eau ou simplement de l'humidité de l'air. Aussi, pour parer à l'inconvénient d'une prise initiale trop rapide, qui s'opposerait au malaxage, on y ajoute du gypse finement pulvérisé dans les proportions de 3 à 4%. La prise initiale se trouve de ce chef retardée d'environ 30 minutes. Le ciment Portland a la composition suivante:

Ca O.....58 à 67%	Mg O.....0 à 5%
Si O_2.....19 à 26%	SO_3.....0 à 2½%
Al_2O_3.....4 à 11%	Na_2 O et K_2O.....0 à 3 %
$Fe_2\ O_3$.....2 à 5%	

Petit Agrégat. On désigne sous le nom de petit agrégat tous les matériaux inertes passant au tamis No. 4. Ce tamis mesure 4 mailles au pouce linéaire et son ouverture libre est de 0.88 pouce carré. Tout sable, pour être utilisé avec succès dans le béton doit remplir certaines conditions sous le rapport du degré de finesse, de sa résistance et de sa pureté. Le module de finesse sera étudié plus loin dans les éléments du calcul des mélanges. Le degré de pureté du sable joue un grand rôle dans la résistance et la durabilité du béton. Aussi, faut-il en tenir compte. La présence de matières organiques, de boue, d'argile, de limon, indique que l'agrégat est d'une valeur douteuse. Ces impuretés se révèlent généralement par un simple examen à l'oeil, ou encore, en frottant un peu de sable sur la paume de la main. On peut évaluer empiriquement le pourcentage de ces impuretés en introduisant un peu de sable dans un bocal d'eau. On agite le mélange puis on le laisse reposer pendant un certain temps. Si la quantité des impuretés ainsi évaluée se révèle supérieure à 5%, le sable doit être rejeté. Si l'on doute de la qualité de l'agrégat sous ce rapport, surtout lorsqu'il s'agit de constructions importantes, l'essai des matières organiques suivant la méthode étalon prescrite dans le cahier des charges de *l'American Society for Testing Materials*, est recommandable.

Gros agrégat. Il est constitué par le matériel de refus au tamis No4. En ce qui concerne le choix du gros agrégat, la même rigueur doit être observée sous le rapport de la pureté. Il importe d'examiner les cailloux attentivement pour s'assurer qu'il n'y adhère pas de glaise, car cette matière empêche la prise du béton et si en l'occurrence la prise s'effectue, le béton se désagrège rapidement. Lorsqu'on n'a pas le choix des matériaux à proximité on peut parer à cet inconvénient en lavant la gravier. Il en est de même pour le sable. La "Canada Cement Company" conseille de procéder comme suit: On construit une auge à fond plat de, 10 à 15 pieds de longueur par 2 pieds de largeur, lui donnant une pente de 1 pied. Le gravier ou le sable est versé dans cette auge sur une épaisseur de 3 pouces, et, à l'aide d'un boyau d'arrosage on y fait couler l'eau par le haut. L'eau coulant sur le plan incliné entraine les impuretés. S'il subsiste encore quelques doutes sur la valeur de l'agrégat quel qu'il soit, il est sage de l'éprouver en préparant une petite quantité de béton suivant les proportions usitées pour le travail projeté. On le met dans une petite boîte qu'on laisse au repos pendant 3 ou 4 jours. Si le mélange durcit et prend l'aspect du béton on peut alors s'en servir avec sureté.

Calcul des mélanges théoriques et pratiques. Nous avons maintenant entre les mains des matériaux d'une valeur connue et approuvée. Allons-nous procéder au mélange? Assurément non. Le danger de s'écarter de la loi d'économie ou de celle de résistance serait imminent. Pour obvier à ce danger il faut opérer méthodiquement en commençant par le calcul du mélange théorique, puis par le calcul du mélange pratique et, en fin de compte, lorsque les calculs sont définitivement établis, l'on procède à la pratique du mélange choisi. Les éléments du calcul des mélanges sont:

1o.—La résistance du béton, liée au rapport de l'eau au ciment.
2o.—Le module de finesse et la grosseur des agrégats.
3o.—L'affaissement.
4o.—Le poids unitaire des agrégats.

Examinons successivement ces divers éléments du calcul.

1o.—La loi du rapport de l'eau au ciment peut s'énoncer ainsi: "Dans des conditions de manipulation et de matériaux donnés, la résistance du béton est uniquement déterminée par le rapport de l'eau au ciment en autant que le ciment est plastique et maniable. Cela veut dire en d'autres termes, que pour un mélange donné constitué de matériaux désirables et effectué dans de bonnes conditions de malaxage et de curage, la résistance à la compression est uniquement fonction d'une variable.....la quantité d'eau employée par unité de ciment.

On peut dire, d'une façon générale, que la résistance est en fonction inverse de cette variable. Cela se déduit aisément du fait que les agrégats sont des éléments purement inertes, tandis que la pâte de ciment constitue un agent actif d'agrégation et d'autant plus actif qu'elle est moins diluée, à condition toutefois qu'elle le soit suffisamment pour entrer en contact avec les matériaux. Un choix judicieux de ce rapport affecte favorablement non seulement la résistance à la compression, mais encore toutes les autres qualités désirables du béton, telles la résistance à l'abrasion, à la flexion, à la corrosion.

Bien que l'essai de la résistance à la compression ne puisse être effectué par le cultivateur ou le technicien agricole, parce qu'ils n'ont pas les instruments à cet effet, il n'est cependant pas dépourvu d'intérêt pour quiconque aime à agrandir le champ de ses connaissances. La méthode est fort simple. Elle consiste à fabriquer plusieurs cylindres de béton au moyen d'un moule de 12 pouces par 6 pouces. Ces cylindres sont chargés au bout de 7 jours jusqu'à rupture. La charge totale divisée par la surface de la base du cylindre donne la résistance au pouce carré à 7 jours. Pour obtenir la résistance à 28 jours, exigée par la méthode étalon, l'on utilise la formule

$$R^{28} = R^7 + 30 \sqrt{R^7},$$

dans laquelle R^{28} désigne la résistance à 28 jours et R^7 la résistance à 7 jours. Il est bien évident que pour obtenir dans la construction projetée une résistance équivalente à celle établie par l'essai, il faut que le malaxage et le curage soient bien effectués.

2o.—*Affaissement.* Il est déterminé en pouces, par la mesure verticale de l'affaissement d'un cône tronqué de béton ayant pour diamètres, 8 pouces et 4 pouces, et pour hauteur 4 pouces. Pour la plupart des constructions rurales on recommande un affaissement de 6 à 7 pouces. Ceci correspond à une maniabilité suffisante pour une mise en place judicieuse, bien que l'on ne possède pas tout l'outillage pour opérer rapidement comme dans l'industrie.

3.—*Module de finesse et grosseur de l'agrégat.* Le module de finesse est déterminé systématiquement au moyen de tamis, et peut être défini de la façon suivante: La somme des pourcentages de refus sur les différents tamis de la série de Tyler, divisée par 100. Or la série de Tyler comprend 9 tamis numérotés comme suit, en se basant sur le nombre de mailles au pouce linéaire: 100 - 50 - 30 - 16 - 8 - 4m - ⅜ - ¾ - 1½. Les ouvertures libres correspondantes sont successivement de 0059 — .0118 — .0236 — .047 — .094 — .188 — .375 — .75 — et 1.7. L'ouverture libre est donc donnée pratiquement double que celle du tamis précédent. Maintenant faisons une analyse de ce genre pour mieux comprendre la définition ci-dessus. Soit à analyser deux agrégats utilisés dans un béton de la formule 1.—2.—4.—L'un des agrégats, le petit, est constitué par du sable; l'autre, le gros, par de la pierre ordinaire. Après avoir tamisé complètement supposons que les pourcentages de refus, calculés en poids de l'échantillon initial, soient tels que représentés dans le tableau ci-dessous.

No. du tamis	Sable	Pierre
1½	0	0
¾	0	25
⅜	0	30
4	15	100
8	38	100
16	50	100
30	75	100
50	88	100
100	100	100
	366	655

Le module de finesse sera donc pour le sable $\frac{366}{100} = 3.66$ et pour la pierre de $\frac{655}{100} = 6.55$.

Comme il s'agit dans le cas qui nous occupe, d'un mélange de 2 agrégats dans le rapport 2:4, il faut nécessairement connaitre le module de finesse du mélange afin de pouvoir en tenir compte, comme nous le verrons plus loin, dans le rapport de l'eau au ciment. Or la valeur (m) du module de finesse du mélange nous est donnée par la formule $m = rmp + (1\text{-}r)mg$, dans laquelle le r représente la rapport du petit agrégat à la somme des valeurs individuelles des deux constituants du mélange considéré, et mp, mg, représentent respectivement les modules du gros et du petit agrégat.

Remplacant les lettres par leur valeur, nous avons:

$$r = \frac{2}{2+4} = \tfrac{1}{3} = .33 \text{ et}$$

$$m = .33 \times 3.66 + (1\text{–}.33)\ 6.55 = 5.5963.$$

Si de la formule $m = rmp + (1\text{–}r)\ mg$ on met r en évidence on a:

$$r = \frac{mg - m}{mg - mp} \text{ d'où en substituant, ou trouve à titre de vérification:}$$

$$r = \frac{6.55 - 5.5963}{6.55 - 3.6} = .33$$

4o.—*Poids unitaire des agrégats.* C'est par définition, le poids d'un pied cube d'agrégats, sec et tassé. Or, dans les conditions ordinaires, le sable et le gravier sont libres et contiennent un certain pourcentage d'humidité. D'où impossibilité de déterminer le volume absolu des matériaux à employer sans connaitre au préalable, les poids unitaires du petit, du gros agrégat et de leur mélange. Pour résoudre ce problême d'une façon adéquate et pouvoir tirer de sa solution des renseignements utiles, il faut d'abord déterminer le poids au cube des agrégats séparés, libres et humides, puis celui de ces mêmes agrégats séchés à l'étuve jusqu'à poids invariable. La différence des deux poids est constituée par le poids de l'eau. On l'exprime en pourcentage du poids de l'échantillon initial. Les poids unitaires des agrégats séparés étant déterminés, on obtient les volumes absolus du petit et du gros agrégat respectivement au moyen des formules:

$$\text{Volume absolu} = \frac{\text{Densité} + \text{Poids unitaire de l'eau.}}{\text{Poids unitaire du petit agrégat.}}$$

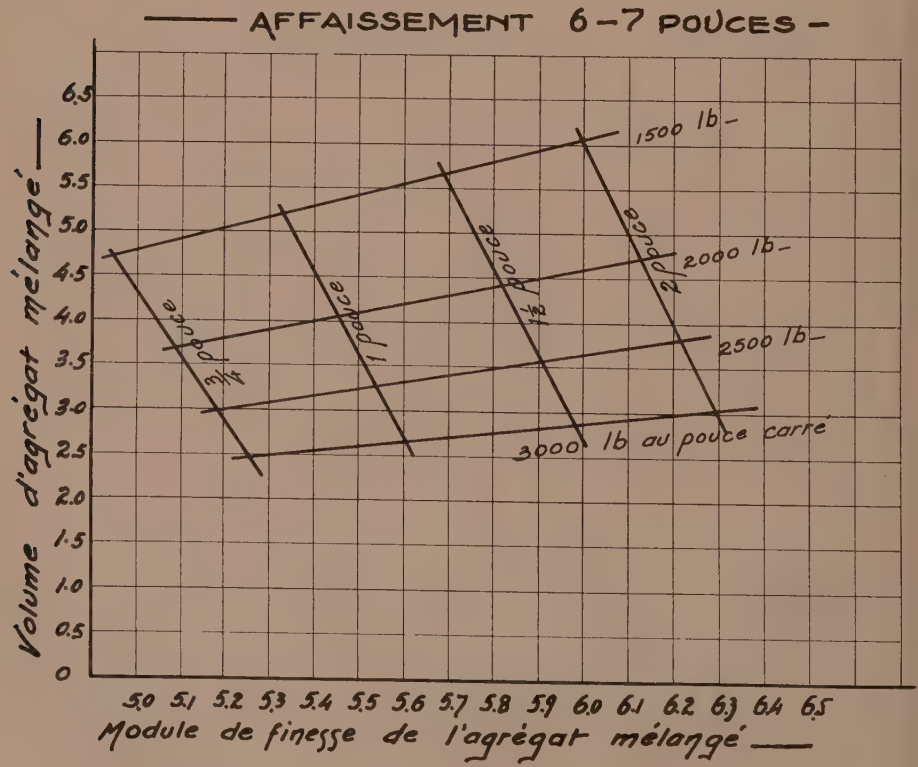
$$\text{Volume absolu} = \frac{\text{Densité} + \text{Poids unitaire de l'eau.}}{\text{Poids unitaire du gros agrégat.}}$$

Pour l'établissement des poids unitaires et des volumes absolus du mélange des deux agrégats, l'on procède de la même façon; mais on fait plusieurs déterminations correspondant à des proportions variables de petits et de gros agrégats. Au moyen des résultats obtenus l'on dresse un diagramme ayant pour ordonnées les poids unitaires et pour abcisses les proportions des deux agrégats dans les divers mélanges. D'où l'on obtient par interpolation une courbe régulière commode pour trouver rapidement les proportions requises pour un mélange d'un poids déterminé.

Calcul du mélange théorique... Il est basé sur les trois facteurs connus suivants: degré d'affaissement, résistance en livres au pouce carré et grosseur maximum de l'agrégat. Sa résolution consiste dans la recherche de ces deux inconnus qui sont le volume et le module de finesse des agrégats mélangés. Pour la recherche de ces deux inconnues, l'on utilise un diagramme indiquant la relation entre la résistance du béton, l'ordre de l'agrégat, le mélange et la consistance. Pour une meilleure intelligence de ce qui précède, faisons un calcul de ce genre. Supposons que l'on veuille construire les fondations d'une grange. Pour de degré d'exposition la résistance désirée est de 15,000 livres, la consistance requise pour une mise en place efficace, nous l'avons déjà dit, est représentée par un degré d'affaissement de 6 à 7 pouces, et la grosseur maximum de notre agrégat relevée par l'analyse au tamis est de 1½ pouce. Pour obtenir une résistance de 1,500 livres, il faut 6 gallons d'eau par sac de ciment, soit un rapport de l'eau au ciment

$$\text{de } \frac{6 \times 10}{62.4} = 0.96.$$

Sur le diagramme ci-contre, nous pouvons lire à l'intersection de la ligne de la résistance de 1,500, et de celle de la grosseur maximum de l'agrégat de 5.7; dont le rapport du ciment à l'agrégat de 1:5.7. Le module de finesse de l'agrégat mélangé nous est fourni par la lecture verticale correspondante: il est de 5.68.



Calcul du mélange pratique. Il consiste à appliquer à bon escient les données fournies par le calcul du mélange théorique. Ainsi, le module du mélange terminé par l'abaque ci-dessus est la résultante des pourcentages de refus de mélange de sable et de pierres et tassé dans des proportions invariables. Ces proportions s'obtiennent au moyen de l'équation—3:

$$r = \frac{6.55 - 5.68}{6.55 - 3.66} = \frac{87}{289} = .30$$

Cela veut dire que le volume des agrégats mélangés est constitué de 30% de sable et de 70% de pierres. Le rapport du ciment au sable est donc dans notre mélange théorique de

$$\frac{1}{.30 \times 5.68} = \frac{1}{1.71}$$ et celui du ciment à la pierre de

$$\frac{1}{.70 \times 5.68} = \frac{1}{3.99}$$

Si, dans les conditions du chantier, le sable contenait par exemple 70% d'humidité, et la pierre, 4%; qu'ils fussent libres et que leur volume augmentasse respectivement de 20% et de 2%, il faudrait naturellement en tenir compte. Le mélange théorique de la formule 1:7.1. =3.99, devient dès lors $1.71 + \frac{(20 \times 1.71)}{100} = 2.05$, et $\frac{3.99 + (2 \times 3.99)}{100} = 4.07$ donc pratiquement 1:2:4.

Pratique du mélange et mise en place. La formation du mélange étant donnée, il convient de calculer la quantité des matériaux requis. Dans le tableau ci-dessous, publié par la Canada Cement Co., nous avons la quantité requise correspondant à des formules différentes.

Matériaux pour une verge cube de béton.

Mélange	Ciment (barils)	Sable. (vg.3)	Pierre. vg. 3
1: 1.5: 3	1.91	0.42	0.86
1: 2: 3	1.74	0.52	0.77
1: 2: 4	1.51	0.45	0.89
1: 2.5: 5	1.24	0.46	0.92
1: 3: 5	1.16	0.52	0.86

Supposons qu'il s'agisse de la construction d'un silo de 15 x 35 pds. dont les parois ont 10 pouces et les fondations 1 pied d'épaisseur. On recommande pour ce construction un mélange de la formule 1:2.5:5 pour les fondations et de 1:2:4 pour le silo proprement dit.

La formule géométrique connue:

$$\times = \left[\left(\frac{d^2 \pi}{4}\right) - \left(\frac{d^2 \pi}{4}\right)\right] - \left(\frac{H}{27}\right),$$

nous permettra de trouver le volume des fondations et des parois de ce silo.

La quantité de béton 1:2.5:5 à employer sera de $\frac{15^2 \times 22 \times 1}{4 \times 7 \times 27} = 6.54$ vg. cubes.

Celui du béton 1:2:4 sera de

$$\left[\left(\frac{15^2 \times 22}{4 \times 7}\right) - \left(\frac{14.16^2 \times 22}{4 \times 7}\right)\right] \frac{35}{27} = 24.9 \text{ vg. c.}$$

Il faudra donc pour occuper le volume exigé par le béton de la formule 1:2:5; 5—

6.54 × 1.24 = 8.11 Barils de ciment.
6.54 × 0.46 = 3.1 vg. 3 de sable.
6.54 × 0.92 = 6.2 vg. 3 de pierre.

et pour celui occupé par le béton de la formule 1:2:4:

soit un total de $\frac{(37.6 + 8.11)}{27} \times 4 = 6.77$ vg. 3 de ciment correspondant à 182 sacs;

11.2 + 3.1 = 14.3 vg. 3 de sable et
6.2 + 22.56 = 28.56 vg. 3 de pierre.

Les matériaux requis étant sur chantier, l'on procède au malaxage en se souvenant que sa durée est un facteur de la résistance. La durée du malaxage a pour minimum une minute et pour maximum 5 minutes. Les conditions de curage sont également un facteur de la résistance. De nombreux essais effectués dans le but de contrôler les conditions de curage judicieux ont démontré que les meilleurs résultats s'obtiennent par un curage à l'humidité de 7 à 10 jours avec une température maximum de 70 F. Dans ces conditions, l'hydratation, phénomene chimique de la prise initiale, s'opère d'une façon plus complète. Il en résulte conséquemment une meilleure structure interne du béton, et partant une imperméabilité plus parfaite.

Considerations Generales

Le béton ayant déjà de nombreuses applications dans les constructions agricoles, il serait intéressant d'en énumérer les plus courantes et de les rapprocher éventuellement de leur degré d'exposition.

Dans cet ordre d'idées, mentionnons la construction des murs de fondation et de soutènement, la construction de silos, de caves à légumes, de citernes, de fosses à fumier, de ponceaux, de glacières, etc.

Les constructions ayant à supporter une forte compression, telles les fondations en général, demandent un rapport étroit de l'eau au ciment. Il en est de même de celles devant faire preuve d'une grande étanchéité, tels que les citernes, les fosses à fumier, etc., car, nous l'avons déjà dit, l'imperméabilité du béton est étroitement liée à la résistance de la compression. De plus, pour ce genre de construction, l'armature est indispensable pour prévenir les fissures. Pour la même raison, la formule du mélange devrait être au moins de 1:2:4.

Tandis que les constructions réclamant une forte résistance à la tension ou à la flexion, sans toutefois qu'une grande imperméabilité soit désirée, tels que les travées, les piquets de clôtures et les murs de plus de trente pieds, (à moins qu'ils ne soient jointés) doivent être armés et demandent par conséquent un rapport plus large de l'eau au ciment pour faciliter l'adhésion à l'armature.

Dans le cas de constructions en hiver, l'entreprise est avantageuse sous le rapport du travail. En cette saison, le cultivateur a plus de temps disponible et la main d'oeuvre plus abondante est à meilleur marché. Les inconvénients bien connus qui font objection à la construction en hiver peuvent être écartés en autant que l'on prenne les précautions nécessaires pour permettre une prise initiale rapide. Ces précautions constituent des moyens préventifs pratiques. Ainsi l'on conseille de chauffer l'eau et les agrégats à 70°F. environ—de faire un curage moins humide qu'en été et de protéger le béton contre le froid pendant les quelques premiers jours qui suivent la mise en place. La vitesse du durcissement peut être augmentée par l'emploi du chlorure de calcium. Ainsi, par l'addition de 2 à 3% de $CaCl_2$, il est possible d'obtenir au bout de 24 hrs. la résistance désirée au bout de 28 jours. Mais ce sel étant assez dispendieux, son emploi n'est pas recommandable au point de vue économique à moins qu'il ne s'agisse de travaux urgents, tels que la construction d'une travée qui s'impose à la hâte, ou encore la construction de supports devant servir à l'installation d'une machine, etc.

Conclusions Pratiques

Nous sommes loin d'avoir épuisé par cet article toutes les connaissances actuelles relatives à la construction en béton, et encore, s'en faut-il qu'elles soient d'application usuelles. C'est pourquoi nous croyons avantageux de synthétiser sous ce titre de "conclusions pratiques" quelques données découlant naturellement de l'exposé ci-dessus, et pouvant servir utilement le cultivateur et le technicien agricole. Donc en résumé, pour obtenir un béton de bonne qualité, c'est-à-dire résistant et durable, il faut:

1o.—Employer des agrégats exempts autant que possible de matières organiques et de terre.

2o.—Employer la quantité d'eau juste nécessaire pour obtenir un mélange maniable.

3o.—Lorsque le malaxage se fait à la machine, que sa durée soit d'au moins une minute; mais jamais supérieure à 5 minutes; l'idéal serait 2 minutes.

4o.—Que la mise en place se fasse rapidement et par couche n'excédant pas un pied d'épaisseur.

5o.—Faire un curage à l'humidité d'au moins une semaine.

6o.—En hiver, réchauffer au moins l'eau à 70°F. et les agrégats si c'est possible; pratiquer un curage moins humide qu'en été et protéger le béton contre le froid avec de la paille, du fûmier, etc.

7o.—Faire des joints dans les murs de plus de 30 pds, sinon, les armer.

8o.—N'employer le $CaCl_2$ que dans les cas d'urgence.

Section de Montréal. La Section de Montréal a eu un dîner-causerie au Cercle Universitaire, le 26 janvier dernier. La conférence fut donnée par Monsieur H. M. Nagant, qui présenta un travail intitulé: "L'état actuel de nos connaissances sur les vitamines". Monsieur Alfred Leclerc, sous-inspecteur des Agronomes, de Laprairie, adressa les remerciements d'usage au conférencier.

Section de Québec. La Section de Québec a dignement clôturé une grande année, par un somptueux banquet organisé le mardi 5 mars, à 7 heures p.m., au restaurant du Parlement, sous la présidence de monsieur Georges Maheux, président sortant.

L'Honorable M. J. E. Perrault, ministre de la Colonisation et Mr. E. S. Archibald, directeur des Fermes Expérimentales du Dominion et président général de la C.S.T.A., étaient les hôtes d'honneur de ce banquet.

Au dessert, monsieur Georges Maheux ouvrit la série des discours en rappelant les principales activités de la Société durant cette année 1928, qui restera mémorable dans les annales de la Section de Québec, surtout par la fameuse convention générale, au mois de juin 1928, qui fut un succès sans précédent.

Le président donna alors la parole à l'honorable ministre Perrault, qui fit ressortir le grand rôle de l'Agronome dans la Province de Québec. Monsieur Henri Lauzière, Agronome du comté d'Arthabaska remercia l'Honorable ministre de la Colonisation. Ce fut ensuite le tour à monsieur J. H. Lavoie, chef du Service de l'Horticulture, de donner une magnifique conférence d'une heure et demie sur l'horticulture dans la Province de Québec. Il serait impossible de donner en quelques mots une appréciation digne de ce travail substantiel et plein de documentation précieuse, aussi nous réservons nous d'en publier les principaux passages dans une prochaine livraison de cette revue.

Monsieur H. M. Nagant se fit l'interprète de la Section de Montréal de la C.S.T.A. pour féliciter les confrères de Québec de leur belle activité durant l'année écoulée et spécialement de cette magnifique séance de clôture. Il adressa aussi quelques paroles de remerciements et de félicitations au conférencier de la soirée pour le magistral travail présenté à cette occasion.

Monsieur E. S. Archibald clôtura cette remarquable soirée par un discours où il insista particulièrement sur la nécessité de promouvoir l'enseignement agricole supérieur et les travaux de recherches scientifiques en agriculture.

Outre l'honorable ministre Perrault, on remarquait encore à la table d'honneur messieurs J. A. Moreau et J. A. Leduc, ministre sans porte-feuille, J. A. Grenier, sous-ministre de l'agriculture et plusieurs membre de la Législature, provinciale de Québec.

Le nouveau bureau de la Section de Québec, pour l'exercice 1929-30, au cours d'une réunion précédant le banquet, a été constitué comme suit:

Président, Monsieur Léo Brown, surintendant des Fermes de Démonstration; vice-président: Monsieur Stanislas Chagnon, assistant-chef du Service de l'Elevage de la Province de Québec; Secrétaire-trésorier, Monsieur Nazaire Parent, assistant-surintendant des Fermes de démonstration.

CONCERNING THE C.S.T.A.

Suggestions for Local Branch Organization and Activities

The President and General Secretary recently visited a large number of local branches throughout Canada, at which members were given an opportunity to discuss the work of C.S.T.A. branches. In the organization of this work it is obvious that local committees are essential, not only to assist standing committees of the parent Society, but also to consider and make effective the local application of the work of these committees. The following are suggestions as to committee organization and lines of work:

MEMBERSHIP

In May, 1929, the Society will publish a second edition of the C.S.T.A. "Who's Who," which will stand as a record of classification of all men associated with professional agriculture throughout Canada and will be used as a reference book not only in Canada but in other countries. There are still some prominent men in Canada, associated with agriculture in administration, education, research and industrial work, who are not members. This is the opportune time for these men to join the Society in order that this publication may be complete. Each local must assume responsibility in this work. The following are suggestions:—

1. That a membership committee be formed in each local.

2. That this committee immediately undertake a survey of all men eligible in their territory who are not members. Prospective members may be found, not only among agricultural college graduates, but also among men engaged in work directly and indirectly affiliated with agriculture, such as (a) the veterinary profession, (b) faculties of natural sciences, agricultural chemistry, etc., of various institutions, including normal schools, and (c) in many lines of modern industry.

3. That this committee solicit membership from these men and, where unsuccessful, present a carefully analyzed report as to the reasons for refusal.

4. That this committee be retained as an active local committee to relieve the local secretary of the full responsibility of maintaining and increasing membership, and to coöperate with the standing committee on membership in any similar campaign work.

EDUCATIONAL POLICY

The splendid work done by Dr. L. S. Klinck from 1920 until 1927 has, in each province, an important local application as yet not realized. Only by the work of an active committee in each local can Dr. Klinck's reports be properly interpreted and steps taken towards re-building educational policies within the province. The following are suggested lines of study and activity on the part of such a committee:—

1. Rural school education should be revised as needed, not only to give necessary elementary education, but to do so in a manner that would not divorce pupils from agriculture, but rather would stimulate interest in better education, with a view towards a career in this profession.

2. In different parts of Canada, high schools are making attempts to teach some agriculture. Unless this is taught by thoroughly qualified men, such an attempt is worse than none. Should not the policy in every province tend toward future specialized agricultural high schools in order to serve the rural boy and girl properly?

3. In our agriculture and allied science degree courses, it is a deplorable fact that throughout our Canadian universities there is an entire dearth of text books which interpret Canadian agricultural problems and results of research. Foreign text books are not applicable to Canadian conditions or to the needs of Canadian students. It is equally apparent that throughout our Canadian institutions there are men in agriculture and agricultural science, eminent authorities in their subjects, who are quite capable of preparing the necessary text books. It is the duty of the C.S.T.A. to encourage such men and to expedite the publication of the desired books. The Committee on Educational Policy might well give this matter special attention, but active work of a committee in each local is necessary.

AGRICULTURAL RESEARCH

There is a marked variation between activity in agricultural research in different provinces. In all provinces there is a varying degree of activity in research in the different phases of agriculture. In many provinces, some of the most important fields of agriculture are as yet undeveloped. In every province, there are numerous institutions created for experimental and research work which, working in greatest harmony, must undertake greater expansion in activity. It is the duty of every local to appoint an active committee which, with the coöperation of leading specialists, will survey the field of needed research, present the findings to the proper institutions and in every way support them in this work.

The standing committee on Research is in the greatest need of assistance of this kind from each local, in order to assist in coördinating interprovincial activity in research.

The C.S.T.A. has in its journal the recognized mouthpiece for results of scientific research in agriculture throughout Canada. The active support of local committees, both directly and indirectly, in this field, is a responsibility which each local must share.

AGRICULTURAL POLICIES

Considerable activity in many of the locals during the past winter will, no doubt, be of great assistance to this standing committee in bringing down its specific recommendations at the forthcoming annual convention.

ECONOMICS (MARKETING EDUCATION)

As an outgrowth of the years of work on marketing education by a standing committee of the C.S.T.A., an Economics Group is being formed in which there should be a group within each local to develop activities and to support the parent group.

SCHOLARSHIPS

This was a standing committee several years ago, but for lack of active support within each local, it could not function to advantage. The effect of

e generous donation of scholarships by the T. Eaton Company but illus-ates the need for scholarships in agriculture and the very beneficial use to nich they can be put.

An active standing committee on Scholarships can be created only if ch local is prepared, in turn, to organize a working committee. There is need for scholarships in every province and there are numerous industries pendent on agriculture which would gladly contribute if properly approach-. The field for scholarships resolves itself into three groups:—

1. *High school scholarships in agriculture.* Something must be done encourage the brightest boys to give at least the same consideration to agri-lture as a profession as to medicine, law, etc. Much could be done by the d of special scholarships to induce our brightest rural and urban boys to ter the agricultural course or science courses allied thereto.

2. *Scholarships for graduate work.* The need for more highly trained en in the specialized aspects of agricultural teaching and research is illus-ated by the numerous positions remaining vacant and the great difficulty in ling them. In 1928 there were seventeen applicants for the T. Eaton Com-ny scholarships who were almost equally qualified, yet only five scholarships ere available. This is an urgent problem and the best results can be ccomplished only by thoughtful energetic work in each local.

3. *Scholarships in phases of science in which Canadian universities e not yet qualified to give graduate work.* Each year there are a few men, pecially fitted for particular lines of work, who must obtain their graduate aining in some other country. Each year, also, research institutions find need for men in a special phase of work for which no one in Canada is as et trained. For example, one leading Canadian institution for a year has een looking for a highly trained man in wool research, in animal genetics, orticultural breeding research, etc. Is it not probable that special phases of dustry might be interested in providing scholarships which would allow the cipients to receive graduate training at leading universities in other countries, pecially qualified to give this work? Several of the locals have a peculiar portunity to function in this way.

PROGRAMME COMMITTEE

There is need for a committee of this kind in each local, to assist in ranging the activities of committees, or of groups within a local, to see at the members have an opportunity to become acquainted with the work f such committees, and to assist and support them. This will permit the sults of the year's work to be submitted through correspondence or dele-ates to the standing committees and annual convention, with the weight of e full local membership. In other words, the committee would have the full sponsibility for arranging the yearly programme of work and entertainment f the local.

GROUP ORGANIZATION IN LOCAL BRANCHES

Each local doubtless offers a different problem in the organization of members into group activities. It is felt, however, that the majority of cals might well be organized for specific work in the four following oups. Even within the membership of a local composed largely of

university men, it has been freely admitted that with the present degree specialization men were not acquainted with the work of others on t campus as they should be. Group organization in itself would large overcome this situation and especially would draw together men who mu associate more closely for the solution of many of Canada's major problen

1. *Animal Production,* including animal husbandmen, poultrym veterinarians, animal chemists, animal bacteriologists, etc. This group wou be a logical sub-group of the Eastern or Western Canada Society of Anim Production, both affiliated with the C.S.T.A.

2. *Agronomy.* This group might include cerealists, forage and fi crop specialists, soil chemists, plant pathologists, entomologists, soil bact iologists, etc. This group would give local support to the Western Canadi Society of Agronomy and, if and when formed, the Eastern Canadi Society of Agronomy.

3. *Horticulture.* This group should include the horticulturists in lines of specialization, including landscape architects, and should have active assistance of plant pathologists, entomologists, apiculturists, chemi etc. In like manner, this group would be supporting the Dominion C.S.T Horticulture group in the development of local activities.

4. *Economics.* This group should include economists, agricultu economists, farm management specialists and a large percentage of n devoting their special activities to general agricultural extension work, cluding marketing of agricultural products.

It is realized that this organization of group activities in each loca a difficult problem and that growth must be gradual and sound. Nev theless, each local might well give this subject special study during next twelve months, and at least make a start in the development of or more groups where useful work may immediately be undertaken.

The above suggestions are offered with the hope that they may, for locals, throw some fresh light on the wide field for work and useful which still awaits the C.S.T.A. and its members in all phases of agricul throughout Canada.

E. S. Archibald, Presid

Exchange of Work Students Between Canada and German

The splendid results which have been derived from an exchange graduate laborers between the United States and Germany by both c tries concerned, created the idea of also extending this exchange to Can

Briefly, the term "work student" means a graduate of either enginee or agricultural sciences, who has an opportunity to profit by doing prac work either in industrial concerns or on farms of a foreign country, possibly combining it with special theoretical courses during the w in one of the best Universities of the same country.

When first negotiating with Canadian authorities about the possibilities of such an extension to Canada much interest and coöperation was shown by such men as Mr. W. J. Egan, Deputy Minister of Colonization, Mr. W. J. Black, Director of Colonization, C.N.R., Mr. H. T. Güssow, Dominion Botanist, and the German Consul General Kempff. These negotiations finally resulted in definite arrangements for the placement of six graduates of German agricultural institutions on Canadian farms during March, 1929.

Mr. W. J. Black, Mr. H. T. Güssow and Mr. H. Kempff expressed their willingness to act as Advisory Board, should the services of such a Board be required.

From the beginning it was the understanding of all parties concerned, that this scheme would be built on a reciprocal basis. In order to accomplish this, the Dresden Headquarters of the German Students Coöperative Association (Wirtschaftshilfe der Deutschen Studentschaft) made a thorough inquiry in regard to all possible opportunities of properly placing graduates of Canadian agricultural institutions on some of the most up to date German farms. The results of this investigation show clearly that wonderful opportunities exist in Germany for a number of Canadian graduates, equal to the number of German graduates taken care of in Canada.

Practical Work on Farms: The German Students Coöperative Association, in this case represented by its Department for the International Exchange of Work Students, promises to place on German farms a limited number of Canadian graduates of agricultural institutions, who have filed their proper application with and have been selected by the Canadian Advisory Board.

The graduates would have to work as regular farm hands for 45 Reichsmark a month and free lodging (room, meals, laundry.) It goes without saying, however, that the farmer will endeavor to give these students such a variety of work that they will get a clear understanding of practically everything. Moreover, the farmers will be pleased to have these students enjoy the utmost social contact possible under such circumstances.

Theoretical Work in Universities: These graduates may work on farms through the whole year, but they may also enter any agricultural institution, to take up some theoretical courses during the winter, if they prefer to do so. For everyone endeavoring thus to broaden his scientific training, the German Students Coöperative Association will procure a free tuition scholarship, so that the student would have to pay his living expenses only.

The German Students Coöperative Association will see that every student is placed according to his special wishes and interests.

A guide book for foreign students, covering all the necessary information on study and life in German Universities has just been published and will soon be available in sufficient copies.

Financing: The student will have to pay his own passage across and back, including railroad fare. During the time the student is doing practical work, he will be able to live on what he earns.

During the time he studies he will have to have about $35—$50 month to cover his living expenses.

Miscellaneous: The best time to go to Germany as a graduate studen laborer is spring. Our experience in handling the work student problen shows that it is better to start with the practical work, in order to improv the student's knowledge of the foreign language to such an extent that h would be able to pursue his studies successfully.

Up to 6 Canadian graduates can be accommodated during the yea 1929. The students should be ready to sail not later than the 10th of May.

The applications should be typewritten and contain the following data (1) Name; (2) Date and place of birth; (3) Permanent address; (4) Grad uated, when and where; (5) Theoretical courses; (6) Details of practical ex perience; (7) Subjects in which the applicant is interested; (8) Whethe or not, where and in what subjects student wants to pursue theoretical studies (9) How much money is at his disposal; (10) Knowledge of the Germa language.

To the application should be attached: (1) Health Certificate, obtaine from a competent physician; (2) One good photograph.

Mr. Black is willing to collect the applications in his department an have the Advisory Board select therefrom as many applicants best suite for this purpose as will not exceed the quota. Enquiries should be addresse to Mr. W. J. Black, Dept. of Colonization, Canadian National Railway Montreal, P.Q.

Convention Programme

The programme for the Winnipeg convention is rapidly approachin completion and will be ready for mailing to each member during the mont of May.

Group meetings in agronomy, animal husbandry, economics and hort culture will be held on the afternoons of June 14th and 15th. One speci lecturer for each of these groups has been invited from the United State and the following have accepted:—

Agronomy—Dr. H. B. Humphrey, Principal Pathologist in charge of cere rust investigations, U.S. Bureau of Plant Industry, Washington, D.C

Animal Husbandry—Dr. W. L. Williams, Emeritus Professor of anim pathology, Cornell University, Ithaca, N.Y.

Horticulture—Dr. M. J. Dorsey, Chief of Pomology, College of Agricu ture, Urbana, Ill.

The United States lecturer in Economics has not yet been chosen.

Each of these lecturers, in addition to speaking at the respective grou meetings, will address an open meeting.

The mornings of June 13th, 14th and 15th will be devoted to busine sessions and the afternoon of June 13th will be occupied by a motor tr to the Dominion Experimental Station at Morden, Man.

Who's Who

All biographies for the "Who's Who" have been submitted to members for approval. It is hoped that this publication can be prepared for printing during April and be mailed before the end of May to those members who have ordered a copy.

Notes and News

P. H. Ferguson (Toronto '20) has been appointed Manager of the Davidson Co-operative Association at Davidson, Sask.

R. F. V. Cooper (McGill '26) has gone to South America to join the staff of the Agricultural Section of the Great Southern Railway of South America (Ferrocarril del Sud). His mailing address is c/o Sección Fomento Rural del F.C.S., Bdo. de Irigoyen 1524, Buenos Aires, Argentina, South America.

Philippe Granger (Montreal '28) has changed his address to Crabtree Mills, P.Q.

S. W. King (Toronto '20), who has been farming at Niagara-on-the-Lake, Ont., for the past seven years is now at Pickering College, Newmarket, Ont.

J. R. Almey (Toronto '21), formerly Horticulturist in the Manitoba Department of Agriculture has been appointed Chief Horticulturist of the Canadian Pacific Railway Co., with headquarters at Winnipeg, Man.

R. P. Charbonneau (Syracuse '23) has changed his adress to 357 St. Joseph Boulevard East, Montreal, P.Q. He is Field Representative of the Canadian Holstein-Freisian Association.

J. H. Bruneau (Montreal '28) is Assistant County Agriculturist at Plessisville, Megantic County, P.Q.

Eric Hearle (Toronto '17), Assistant Entomologist under the Dominion Entomological Branch, has been transferred from Indian Head, Sask., to Kamloops, B.C.

F. L. Drayton (McGill '14) is taking graduate work at Cornell University towards a Ph.D. degree. His mailing address is 409 Dryden Road, Ithaca, N.Y., U.S.A.

J. P. Ficht (Alberta '24) has changed his address to Didsbury, Alta.

Conrad Turcot (Montreal '24) is taking graduate work at the University of Wisconsin in plant breeding as applied to tobacco. His address is 201 North Park Street, Madison, Wis., U.S.A.

H. M. McElroy (Toronto '13), who has been Superintendent of the Ontario Provincial Industrial Farm at Fort William, Ont., for the past eight years, has resigned to become District Manager for Northwestern Ontario, of the Ontario Equitable Life and Accident Insurance Company,

with headquarters at Fort William, Ont. He took over his new duties on March 18th.

G. H. Bowen (McGill '23), who is taking special courses in Landscape Architecture at Columbia University, has changed his mailing address to Apt. 6-D, 530 Riverside Drive, New York City.

L. A. Tremblay (Laval '28) has received the appointment of Assistant County Agriculturist at Ville-Marie, P.Q.

C. A. Zavitz (Toronto '88) has been spending the winter months in Florida, but expects to return about April 5th. After that date his address will be R. R. No. 2, Ilderton, Ont.

Nazaire Parent (Laval '26) who has been on the staff of the Entomological Branch of the Quebec Department of Agriculture for the past two years has been appointed Assistant Superintendent of Demonstration Farms.

J. D. Lanthier (McGill '25) has resigned his position as Advertising Manager of *Farm and Dairy*, Peterboro, Ont., to take charge of Live Stock advertising for the *Ontario Farmer*, Toronto, Ont.

C. D. Fogerty (McGill '25) now owns and operates a poultry farm near Galt. His mailing address is R. R. No. 3, Galt, Ontario.

M. C. McPhail (Toronto '21), Agricultural Representative in York County, Ont., has received the appointment of Assistant Director of Agricultural Representatives for Ontario with headquarters at Toronto, Ont.

Applications for Membership

The following applications for regular membership have been received since February 1, 1929:—

Baird, F. F. (Toronto, 1928, B.S.A.), Gagetown, N.B.
Breakey, W. J. (Manitoba, 1928, B.S.A.), Morden, Man.
Broun, Erdman, (Manitoba, 1928, B.S.A.), Morden Man.
Collins, M. A. (Saskatchewan, 1928, B.S.A.), Saskatoon, Sask.
Hunt, E. C. (Washington State College, 1912, B.Sc.), Nelson, B.C.
MacEwan, J. W. G. (Iowa State College, 1928, M.S.), Saskatoon, Sask.
Steves, H. L. (British Columbia '24), Steveston, B.C.

Local secretaries may now accept applications for membership for the year ending May 31, 1930, without making any charge for the remaining two months of the current year. Graduates of 1928, members of the Eastern or Western Canada Society of Animal Production, and of the Western Canadian Society of Agronomy, are not required to pay any initiation fee.

Applicants joining the Society before April 30, 1928, will be included in the "Who's Who", to be published in May.